NASA TM-89241

Research and Technology Objectives and Plans

SUMMARY

NASA
National Aeronautics and Space Administration

FISCAL YEAR 1987 RESEARCH AND TECHNOLOGY PROGRAM

January 1989

INTRODUCTION

This publication represents the NASA research and technology program for FY 1987. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and abstracts of the RTOPS. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

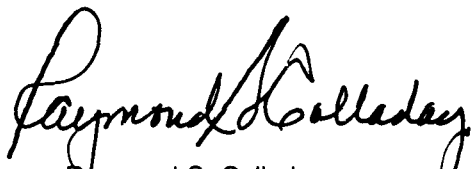
The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the NASA responsible organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary.*

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contact which might be disruptive to ongoing research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, D.C. 20546
Attn: Edmund L. Sanchez
Deputy Director for Resources (RI)



Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology

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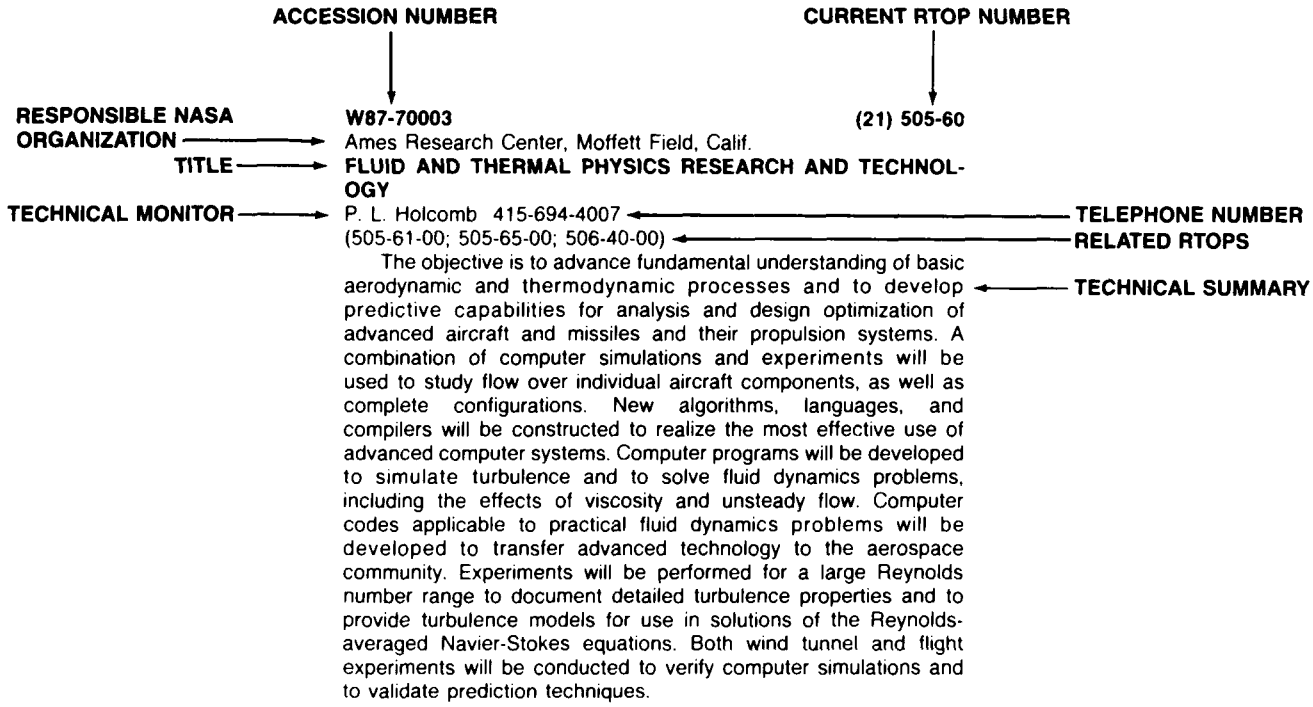


The objective is to advance fundamental understanding of basic aerodynamic and thermodynamic processes and to develop predictive capabilities for analysis and design optimization of advanced aircraft and missiles and their propulsion systems. A combination of computer simulations and experiments will be used to study flow over individual aircraft components, as well as complete configurations. New algorithms, languages, and compilers will be constructed to realize the most effective use of advanced computer systems. Computer programs will be developed to simulate turbulence and to solve fluid dynamics problems, including the effects of viscosity and unsteady flow. Computer codes applicable to practical fluid dynamics problems will be developed to transfer advanced technology to the aerospace community. Experiments will be performed for a large Reynolds number range to document detailed turbulence properties and to provide turbulence models for use in solutions of the Reynolds-averaged Navier-Stokes equations. Both wind tunnel and flight experiments will be conducted to verify computer simulations and to validate prediction techniques.

RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

a summary

FISCAL YEAR 1987

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

Fluid and Thermal Physics Research and Technology

W87-70001 **(23) 505-60**
Langley Research Center, Hampton, Va.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-865-3285

The objective is to advance the computational and experimental state of the art in a broad range of fundamental technologies areas and to promote the synergistic evolution of innovative, high risk concepts and technologies needed for the efficient design of advanced civil and military aircraft. Solution methodology will be developed for a variety of viscous and inviscid equation sets including the full Navier-Stokes equations and applied to increasingly complex configurations across the speed range from subsonic to hypersonic. Detailed critical experiments will be performed to validate new computational methods and to improve the fundamental understanding of complex fluid physics and chemistry processes. This improved understanding will be applied to the development and evaluation of innovative concepts for reducing aircraft drag or increasing propulsive efficiency of scramjet-type engines. Particular emphasis will be placed on developing aerodynamic concepts and design methodology for practical, rel. .ble, and maintainable viscous drag reduction. Improved aircraft design methodology will be validated using data from flight tests, from numerous ground facilities, and from the high Reynolds number data base being generated in the National Transonic Facility.

W87-70002 **(55) 505-60**
Jet Propulsion Laboratory, Pasadena, Calif.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
L. M. Mack 818-354-2138

This part of the Viscous Flows element of the Fluid and Thermal Physics Research and Technology program applies to the research area of laminar instability and transition. The overall objective is an understanding of the detailed physical processes that lead to boundary-layer transition, and the application of this knowledge to the prediction of transition. The plan is to use experimental, analytical, and numerical techniques to investigate the following four problems: (1) the mechanism by which instability waves are produced by various external disturbance sources, and the determination of their initial conditions (receptivity problem); (2) the propagation of the resultant instability wave trains and wave packets through the boundary layer to the point where turbulence first appears; (3) the development of a rational method for the prediction of transition; and (4) passive and active methods of transition control. As knowledge of transition is important for aircraft performance in all speed ranges and for all aerodynamic surfaces, the research will encompass two- and three-dimensional incompressible, transonic, supersonic, and hypersonic boundary layers.

W87-70003 **(21) 505-60**
Ames Research Center, Moffett Field, Calif.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
P. L. Holcomb 415-694-4007
(505-61-00; 505-65-00; 506-40-00)

The objective is to advance fundamental understanding of basic aerodynamic and thermodynamic processes and to develop predictive capabilities for analysis and design optimization of advanced aircraft and missiles and their propulsion systems. A combination of computer simulations and experiments will be used to study flow over individual aircraft components, as well as complete configurations. New algorithms, languages, and compilers will be constructed to realize the most effective use of advanced computer systems. Computer programs will be developed to simulate turbulence and to solve fluid dynamics problems, including the effects of viscosity and unsteady flow. Computer codes applicable to practical fluid dynamics problems will be developed to transfer advanced technology to the aerospace community. Experiments will be performed for a large Reynolds number range to document detailed turbulence properties and to provide turbulence models for use in solutions of the Reynolds-averaged Navier-Stokes equations. Both wind tunnel and flight experiments will be conducted to verify computer simulations and to validate prediction techniques.

Applied Aerodynamics Research and Technology

W87-70004 **(23) 505-61**
Langley Research Center, Hampton, Va.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285

The objective is to provide the analytical and experimental research and technology development necessary for an advanced and validated base of new aerodynamics technology for application to future generations of military and civil aircraft. The specific research thrusts are to achieve improved accuracy in wind-tunnel and flight testing to support advanced aircraft and missile development; develop revolutionary advances in efficiency and productivity for a new generation of subsonic aircraft as well as safety and efficiency of general aviation aircraft; develop the aerodynamic technology base necessary for the design of future

fighter aircraft concepts; provide a fundamental understanding for prediction and control of aeroacoustic phenomena on advanced aerospace vehicles; and develop the technology to solve helicopter noise and vibration problems as well as reduce pilot workload in adverse environments. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objective. In addition, technical assistance is provided to DOD, other agencies and industry consistent with available resources.

W87-70005 **(55) 505-61**
Jet Propulsion Laboratory, Pasadena, Calif.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
V. Sarohia 818-354-6758

The overall objective of this research program is to develop a non-intrusive technique to make automated multi point velocity measurements in both water and air utilizing digital image processing. At the present time, luminescent particles in water are being employed as flow tracers and double pulsed laser photography is used to record the images. Future plans, however, include the use of helium bubbles to extend the use of this technique to air flows. The eventual goal of this RTOP is to apply the technique to full-scale applications. The near term objectives are to accomplish particle traces below the surface of the liquid air interface. The test flow field chosen is that of a vortex sheet in the wake of a circular cylinder.

W87-70006 **(21) 505-61**
Ames Research Center, Moffett Field, Calif.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
B. A. Lampkin 415-694-6039
(505-60-00)

The overall objective of this activity is to provide the necessary research and technology development for an improved validated base of new aerodynamics technology for application by industry to future generations of both civil and military flight vehicles. The approach will be to conduct analytical, ground based, and flight research test investigations of a broad class of vehicles, which shall include subsonic transport and general aviation aircraft, rotorcraft, advanced fighter/attack aircraft, powered lift configurations (STOL, V/STOL and STOVL) and hypersonic vehicles. The analytical effort will include the coupling of TFAR2 with the integral code CAMRAD for the computation of transonic flow about the H34 main rotor. This RTOP includes the development of wind tunnel instrumentation. Computational chemistry calculations will be performed to study hydrogen-air chemistry and the composition of air surrounding vehicles traveling at hypersonic velocities.

Propulsion and Power Research and Technology

W87-70007 **(23) 505-62**
Langley Research Center, Hampton, Va.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285

Advanced experimental and analytical techniques are used to develop all technology areas for airbreathing hypersonic propulsion concepts, to develop the technology to significantly improve the performance potential of hypersonic flight vehicles including an understanding of and solutions to problems inherent to such vehicles, and to provide basic information on the effect of advanced propulsion concepts on the performance and interference characteristics of advanced aircraft. Analytical and experimental studies using advanced facilities and techniques are utilized by unique personnel to investigate scramjet engine components, complete subscale engines, problems inherent to such engines, engine/airframe integration and improvement of hypersonic aerodynamic performance. In addition, advanced aircraft configurations and generic models are used for investigations of thrust vectoring and reversing, 2-D nozzles and propulsion control, and nacelle/wing interactions. Computational methods and unique experimental procedures are developed to help understand the flow phenomena associated with hypersonic propulsion and inlet and nozzle integration.

W87-70008 **(22) 505-62**
Lewis Research Center, Cleveland, Ohio.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The broad objective is to explore and develop the technologies for the propulsion systems of advanced VSTOL supersonic and hypersonic cruise aircraft, rotorcraft, and smaller conventional aircraft. In-house, contract, and grant research and development efforts will address various components such as inlets, engines, nozzles, ejectors, fans, and helicopter transmissions, as well as unique propulsion systems, and propulsion/airframe integration. Improved instrumentation and controls will be developed, and internal computational fluid mechanics capabilities will be enhanced by test and analysis.

Materials and Structures Research and Technology

W87-70009 **(23) 505-63**
Langley Research Center, Hampton, Va.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-865-2042

This research includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) thermal structures, aeroelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) aeroacoustics and structural acoustics; and (5) interdisciplinary analysis and optimization. Principal research objectives include providing structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. The experimental portion of the program emphasizes laboratory experiments that utilize the Structures Directorate unique resources which include testing facilities and highly trained personnel.

W87-70010 **(10) 505-63**
National Aeronautics and Space Administration, Washington, D.C.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. L. Venneri 202-453-2760

The objective is to conduct fundamental research on advanced materials concepts for aeronautics. The interdisciplinary program in polymeric composites includes research into the properties of the constituent fibers and matrix properties, advanced structural analysis methods, fatigue response of laminates, environmental response modeling, and processing science for light weight airframe structures. The interdisciplinary project in ceramic materials addresses critical research in material performance and design methodology as related to brittle materials. Emphasis will be placed on understanding the processing and properties of these materials. Activities include fundamental characterization of silicon nitride and silicon carbide materials, environmental response processing science, and impact behavior of high temperature ceramic bodies for gas turbine engine applications. Advisory services to guide R&D in advanced aerospace materials are provided by the National Materials Advisory Board, a unit of the National Academies of Science and Engineering.

W87-70011 **(21) 505-63**
Ames Research Center, Moffett Field, Calif.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. M. McKeithan 415-694-5020

The overall objective is to provide the materials, structures, and acoustics research and technology development necessary for significant improvements in the performance, durability, utility, and economy of future generation civil and military aircraft. Fundamental experimental and analytical research on advanced composites will be performed to better characterize and understand fatigue and fracture behavior in order to predict accurately the service life of structures when exposed to their environments. Aeroelastic characteristics of new vehicle configurations (X-29, etc.) will be investigated, new flight load and deflection measurement techniques developed, and analysis codes evaluated through correlation with measured values. A major technical effort is devoted to improving the understanding and capabilities to predict rotorcraft dynamic behavior and aeroacoustics. Detailed airloads, acoustic signatures, rotor loads and dynamic stability data will be obtained for a modern four-bladed rotor and a high-speed rotor, and prediction codes evaluated and improved using the measured data.

W87-70012 **(22) 505-63**
Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193
(533-00-00; 505-66-00)

The major objectives of this RTOP are to: (1) advance the level of materials and processing technologies for high-temperature metallic, polymeric, and ceramic materials in order to contribute to improving the performance, life, reliability, structural efficiency, and/or to reducing the cost of future turbine engines (the prime emphasis of the work is directed toward developing greater understanding of the interrelationships between material composition/microstructure, fabrication processes, and mechanical/physical properties); (2) develop and verify advanced analysis and synthesis methods, advanced generic structural concepts, and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components. In addition, to develop and experimentally validate improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems.

Information Sciences Research and Technology

W87-70013 **(62) 505-65**
Marshall Space Flight Center, Huntsville, Ala.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
G. D. Cassimus 205-544-1560

The objective of this effort is to obtain a complete end-to-end high speed mainframe Computer Networking Subsystem (CNS) including its operation and maintenance utilizing the Program Support Communications Network (PSCN) as the communications medium. This subsystem is to provide for the sharing of unique mainframe computational capabilities embodied in the various large scientific computers located at NASA Centers. CNS must be adaptable to changes in the volume of traffic, number of mainframes at each site, mainframe operating systems, number of sites, and rate of data transfer. The initial system will link the unique computational capabilities of the OAST Centers. The system to support this link will consist of data buffering and mainframe interface equipment, and utilize the NASA PSCN as the communications medium.

W87-70014 **(23) 505-65**
Langley Research Center, Hampton, Va.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915

Non-traditional computer architectures offer increased performance and greater reliability. The concurrent processing research here addresses systems issues and distributed operating systems (DOS) to improve these qualities. A disciplined approach to software development and automated tools are needed to construct reliable software for flight crucial systems. The software engineering research will characterize and evaluate automated support tools for software specification, design, code, and management; create guidelines for developing software with fault-tolerant features, and for measuring software reliability. Concurrent processing issues include communication and synchronization; programming languages and environments; problem decomposition and algorithm development; and comparison of several prototype architectures for real-time computing. DOS facilities to aid in program control and debugging will be explored. Analysis of fault-tolerant software techniques applied to a realistic flight software problem will be conducted and automatic generation of selected programming constructs will be investigated. A prototype environment for management/control of software projects has been defined and will be delivered. Much of the parallel computing systems research will be performed at the Institute for Computer Applications in Science and Engineering. A block grant in computer science at the University of Illinois will support several related research tasks.

W87-70015 **(21) 505-65**
Ames Research Center, Moffett Field, Calif.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
M. C. Smith 415-694-5188
(505-60-00; 506-43-00)

The objective is to support computational fluid dynamics (CFD), computational chemistry, and other disciplines of Agency interest by developing an understanding of the relationships and tradeoffs between algorithms and computer architectures for these applications. Approaches, techniques, and tools are needed to apply this insight to the development of optimal hardware/software systems for this class of problems. The research will permit better utilization of emerging concurrent processors, and will influence the design of systems crucial to NASA in the 1990's. The approach involves collaboration of the Computational Research Branch and Research Institute for Advanced Computer Science (RIACS). This collaboration will bring together computer science and computational physics expertise to analyze the requirements, evaluate extant concepts and products, and conduct the necessary research and development. The steps involved include: the development of requirements and evolution of promising systems concepts; simulation, emulation, or modeling techniques to validate system concepts; and the building of prototypes to serve as proof of concept.

Controls and Guidance Research and Technology

W87-70016 **(23) 505-66**
Langley Research Center, Hampton, Va.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915

The overall objective of this RTOP is to provide for the necessary research and technology development leading to improved civil and military aircraft operations under all weather conditions and for the exploitation of new controls and guidance concepts and hardware to increase the efficiency, effectiveness, and safety of new military and civil aircraft. Research activities under this RTOP will be directed toward establishment of a technology base for highly augmented aircraft handling qualities criteria, multidisciplinary control law analysis and synthesis techniques, improved display design concepts, flight crucial systems, and system concepts and procedures enabling safe and efficient operations in the evolving National Airspace System.

Analytical and experimental techniques will be developed to exploit advanced electronic and computer based flight systems concepts for improving efficiency and performance of future civil and military aircraft. Emphasis will be placed on increasing levels of integration and on exploiting multidisciplinary interactions.

W87-70017 **(51) 505-66**
Goddard Space Flight Center, Greenbelt, Md.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
D. G. Roberts 804-824-3411

The overall objective of this RTOP is to provide for operational support to approved OAST projects utilizing the Goddard Space Flight Center/Wallops Flight Facility (GSFC/WFF) research airport. Operational support includes: project coordination; program aircraft fuel and ground servicing; control tower management of the GSFC/WFF research airport control area; shop support; ADP operations; SAR, chase, and other aircraft flight services; crash, fire, and rescue services; specialized instrumentation and miscellaneous equipment.

W87-70018 **(21) 505-66**
Ames Research Center, Moffett Field, Calif.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
G. W. Condon 415-694-5567
(505-66-00; 533-00-00)

The objective of this research is to develop a guidance and control technology base for design of safe, efficient, civil and military aircraft. Research will be conducted on: advanced, robust flight/propulsion control systems for state-of-the-art and superaugmented aircraft; advanced guidance and display systems which fully utilize the computational capabilities for artificial intelligence and expert systems which permit more efficient operations in the air traffic control (ATC) environment; advanced analysis techniques to enhance our knowledge of atmospheric processes and other causes of aircraft accidents by analyzing data from accidents in conjunction with the National Transportation Safety Board (NTSB); application of expert system, computer vision, and advanced guidance technology to enable automated rotorcraft flight in the map-of-the-Earth; application of expert system techniques to develop an automated wingman for fighter/attack aircraft; and controls and guidance requirements for the National Aerospace Plane (NASP). The approach will be to conduct analytic studies, evaluate concepts on flight simulators, and validate the more promising concepts in flight.

Human Factors Research and Technology

W87-70019 **(23) 505-67**
Langley Research Center, Hampton, Va.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915
(505-66-00)

The overall objective of this RTOP is to provide a research and technology data base from which solutions to human problems impeding the growth and safety of air transportation may be derived. Specific objectives include: the exploration and development of concepts for integrated display and information transfer between crew and aircraft; the application of artificial intelligence concepts to cockpit aids such as system status monitoring and diagnosis to facilitate safe and efficient flight operations; the exploration and development of innovative control/display operational concepts involving cockpit displays of flight management information that will insure the efficient and safe use of ATC system technology; the development and validation of human response measurement technologies for the assessment of aerospace crew mental state; the establishment of a quantitative and qualitative data base for display format/arrangement factors; and the development of a technology base that will allow reliable substitution of simulators for research applications involving atmospheric environment factors.

W87-70020 **(10) 505-67**
National Aeronautics and Space Administration, Washington, D.C.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
Lee B. Holcomb 202-453-2747

This RTOP provides support for NASA's joint sponsorship with the Office of Naval Research (ONR), the Army Research Institute (ARI), and the Air Force Office of Scientific Research (AFOSR) of the National Academy of Sciences (NAS) Commission on Behavioral and Social Science (CBASS) Committee on Human Factors. The National Academy of Sciences and its committees provide advice to governmental agencies in solving advanced technological problems. The Committee on Human Factors was established to provide advice on determining the most important theoretical and methodological issues in human factors.

W87-70021 **(21) 505-67**
Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
D. C. Nagel 415-694-5729
(506-47-00; 199-22-00)

Human error is involved in a high proportion of all aircraft accidents. Accident and incident reports document both system design and operations factors in the causal chain leading to aviation human errors. Advances in the ability to automate aircraft, designed to decrease the potential for human error, continue to dramatically alter the role of the pilot. Similar advances in computer graphics, image processing, and display technologies are revolutionizing the manner in which information can be managed in the cockpit. These advances can fundamentally improve system performance if designed properly. To minimize human error, advanced technology must be designed with crewmember capabilities and limitations explicitly accounted for. The program is designed to determine characteristic relationships between human error and various approaches to flight deck automation; identify, develop, and evaluate methods for designing error tolerant cockpit systems; develop the predictive technology needed for optimal cockpit design, incorporating electronic displays, advanced input hardware and software, and intelligent automated systems; develop techniques to analyze, predict and train crew performance in advanced cockpit environments, and under normal and adverse conditions. The unique problems of civil air transport and rotorcraft will be addressed.

Flight Systems Research and Technology

W87-70022 **(23) 505-68**
Langley Research Center, Hampton, Va.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. V. Harris 804-865-3285

The goal of this research is to improve the knowledge of severe storm atmospheric processes as they affect the design and safe and efficient operation of aircraft and aircraft systems. Existing experimental programs will be continued to provide additional data for improving the detection and avoidance of severe storm hazards, and for the development of design and operating criteria for those hazards which cannot be avoided. Specific hazards include precipitation, wind shear, turbulence, and in-flight lightning. The approach will be to develop advanced methods and vehicle concepts needed to significantly increase fighter maneuverability considering such effects as high angle of attack, separated flow conditions, vortex flaps, and thrust vectoring; and utilize flight experiments to validate key elements.

W87-70023 **(21) 505-68**
Ames Research Center, Moffett Field, Calif.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
D. H. Gatlin 805-258-3166
(533-00-00)

The overall objective is to provide for the research and technology development of advanced flight systems needed for future military and civil aircraft. Research will be initiated in support

of high angle-of-attack flight investigations with an F-18 test aircraft. Near term emphasis will be on enhancing the understanding of forebody vortex flow and in development and refinement of aerodynamic predictive techniques. A longer-term objective will be to design, develop, and evaluate a thrust vectoring capability to augment conventional flight control effectors at high angle-of-attack. Program objectives will be accomplished by analyses, design, ground-based simulations, wind tunnel testing, and flight research. A contractor SBIR program will be conducted to develop, fabricate, and conduct wind tunnel tests of a full-scale joined wing aircraft design. The incorporation of this technology into a variety of modern aircraft designs will be investigated. Ames-Dryden will support the program in an advisory role and during formal program reviews. In support of the U.S./U.K. ASTOVL Aircraft Technology Program, contracted efforts will be conducted to evaluate supersonic single-engine concepts featuring four different propulsive lift systems.

W87-70024 **(22) 505-68**
Lewis Research Center, Cleveland, Ohio.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The overall objective of this effort is to provide for the research and technology development of advanced flight systems needed for future military and civil aircraft. This part of the flight systems R&T program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil rotorcraft and propulsion and control problems associated with operation of military high performance STOVL aircraft. The current plans for this research area are to develop analytical and experimental simulation techniques to study aircraft icing problems and to develop advanced ice protection system concepts to improve aircraft productivity, operational capability and safety, and to identify and develop propulsion technology for supersonic STOVL aircraft.

Systems Analysis

W87-70025 **(23) 505-69**
Langley Research Center, Hampton, Va.
SYSTEMS ANALYSIS
R. V. Harris 804-865-3285

The overall objective of this RTOP is to provide long-term guidance and direction to the aeronautical research and technology programs performed by NASA and the aviation industries. This will be accomplished primarily through the conduct of long-range planning and in-house studies directed to the analysis of advanced concepts for future civil and military aircraft design. Assessments of the feasibility and potential benefits of highly integrated configurations incorporating improved aerodynamics and advanced propulsion, propulsion-airframe integration and controls, and structures and materials will be made. Tradeoff and sensitivity analyses to identify optimum parameters and the potential value of the discipline technology improvements will be conducted for subsonic, transonic, supersonic, and hypersonic vehicles with particular emphasis on the latter two-speed regimes.

W87-70026 **(21) 505-69**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSIS
J. Zuk 415-694-6568

The overall objective of this activity is to provide an information data base for advanced planning of rotorcraft research programs. This information will lead to the development of technology which will advance the state-of-the-art of rotorcraft. Emphasis will be on promising technologies which will enable new or greatly increased capabilities of rotorcraft vehicles, innovative and/or beneficial uses of rotorcraft, and the application of emerging technologies to rotorcraft. The feasibility, potential benefits, and critical technologies of advanced rotorcraft concepts will also be assessed.

W87-70027 **(22) 505-69**
Lewis Research Center, Cleveland, Ohio.
SYSTEMS ANALYSIS
D. C. Mikkelson 216-433-5637

To perform studies of the feasibility and potential benefits of advanced subsonic, supersonic, and hypersonic propulsion concepts, to identify technology research requirements and define opportunities for capitalizing on technology advances. Studies will be performed on a wide variety of engine cycles, propulsion systems, and engine/airframe combinations in aircraft missions. Near term and long range aero-propulsion planning will be conducted to assist in the development of future NASA aeronautics programs.

W87-70028 **(10) 505-69**
National Aeronautics and Space Administration, Washington, D.C.
SYSTEMS ANALYSIS
Cecil R. Rosen 202-453-2792

The objective of this effort is to provide for various activities in support of the Aeronautics Studies program. These activities include a studies contract in support of OAST aeronautics technology program requirements, assessments, planning and advocacy, as well as a continuation of support of the Radio Technical Commission for Aeronautics (RTCA).

Interdisciplinary Technology

W87-70029 **(23) 505-90**
Langley Research Center, Hampton, Va.
INTERDISCIPLINARY TECHNOLOGY
J. C. South 804-865-2664
(506-90-00)

The goal of this RTOP is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. This is accomplished through three program elements: (1) The Fund for Independent Research (FIR); (2) The Graduate Program in Aeronautics (GPA); and (3) Joint University Institutes (JUI), which includes the Joint Institute for Advancement of Flight Sciences (JIAFS) and the Institute for Computer Applications in Science and Engineering (ICASE). FIR funds novel, long-range, high-risk, basic research investigations in engineering and physical sciences related to aeronautics through the support of unsolicited proposals from the university community; GPA sponsors graduate training and research that is relevant and acceptable to both NASA and the university in the field of aeronautics and encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training. A significant portion of the training will be through student research conducted with faculty support at a NASA Center using NASA facilities. The JUI provides a core level of funding for the promotion of an active NASA/university interchange in order to maintain cooperative, innovative, venture research at the edge of the latest technology and techniques in science, engineering, mathematics, and computers.

W87-70030 **(21) 505-90**
Ames Research Center, Moffett Field, Calif.
INTERDISCIPLINARY TECHNOLOGY
M. Omura 415-694-5113

The objective of this RTOP is to promote and maintain innovative, high-risk, university-based basic research in aeronautics through research and training grants, cooperative research efforts, and a joint research institute. The objective is accomplished through three elements within the RTOP: Funds for Independent Research; Aeronautics Graduate Research Program; and a Joint University Institute. Funds for Independent Research support innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. Aeronautics Graduate Research Program provides grants to support graduate training and research in aeronautics. A significant portion of the training

will be through student research conducted at Ames Research Center. The Joint University Institute element provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics. The Institute promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics.

W87-70031 **(22) 505-90**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY TECHNOLOGY
M. J. Hartmann 216-433-2954

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. The program is carried out primarily through grants which are selected by the Chief Scientist with the aid of the Research Advisory Board. It allows OAST to initiate fundamental studies in areas not presently included in a specific discipline program and to sponsor graduate training in aeronautics. The funds are also used to bring speakers and visiting university scientists to the Center and to hold workshops and seminars.

W87-70032 **(10) 505-90**
National Aeronautics and Space Administration, Washington, D.C.
INTERDISCIPLINARY TECHNOLOGY
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for various support activities of the Aeronautics Research and Technology program. These activities include the acquisition of office automation equipment, software and support services; technical, administrative, and general support services; the Resident Research Associateship (RRA) program; the conduct of reviews, studies and assessments of the ongoing and planned programs by the Aeronautics and Space Engineering Board (ASEB); the large-scale scientific computing program; and hypersonic training and research. Purchases of office automation equipment and software are handled in accordance with established agency procedures. Support services, the RRA program and the ASEB are contracted efforts, and the large-scale scientific computing program and hypersonic training and research will include university grants.

Aeronautics Systems Technology Programs

Rotorcraft Systems Technology

W87-70033 **(23) 532-06**
Langley Research Center, Hampton, Va.
ADVANCED ROTORCRAFT TECHNOLOGY
C. P. Blankenship 804-865-2042
(505-61-00)

The objective is to develop the technology for improving rotor noise methodology and noise design criteria for both military and civil rotorcraft. The approach is to acquire acoustic data from tests of a variety of rotor and rotor system configurations and to utilize these data to develop and verify advanced noise prediction methods. This research is performed through contracts with major U.S. manufacturers of helicopters and is coordinated with in-house aeroacoustic research at Ames and Langley and with company independent research.

W87-70034 **(21) 532-09**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY FOR NEXT GENERATION ROTORCRAFT
J. W. Lane 415-694-6576

The goal of this Program is to adequately develop and demonstrate specific X-Wing technology such that this proof-of-concept flight investigation program coupled with the successful completion of the DARPA/NASA Convertible Engine Program and the DARPA/Army NOTAR (No Tail Rotor) Program would provide the necessary technology base such that a low risk development program could be initiated for an X-Wing prototype vehicle. The X-Wing is a four-bladed extremely stiff rotor utilizing circulation control aerodynamics for lift and rotor control, which is stoppable in flight. When stopped, the rotor/wing becomes two forward swept and two aft fixed wings in an 'X' configuration. For the X-Wing flight experiment one RSRA will be configured as a compound helicopter using an X-Wing rotor system driven by two GE T-58 engines that will also drive a compressor through a modified S-61 gearbox and clutch. A digital fly-by-wire flight control system will be developed to control the rotor utilizing higher harmonic control and hub moment feedback. This approach includes detailed analysis, design, fabrication, ground tests, and flight testing of an X-Wing rotor system, modifications required to the RSRA (Rotor Systems Research Aircraft), and supporting analysis, wind tunnel testing, and simulation.

High-Performance Aircraft Systems Technology

W87-70035 **(23) 533-02**
Langley Research Center, Hampton, Va.
HIGH-PERFORMANCE FLIGHT RESEARCH
R. V. Harris 804-865-3285
(505-68-00)

The objective of this RTOP is to provide improved design methods for highly maneuverable aircraft in the areas of aerodynamic performance, stability, and control with emphasis on moderate and high angles of attack. More specifically, work will be focused on validating design methods for the vortex flap concept and validation/demonstration of high angle-of-attack aerodynamic technology applicable to fighter airplanes. The approach to be used will combine full-scale flight and wind tunnel testing in both areas of emphasis. The LaRC F-106 will be equipped with a ground-adjustable vortex flap which was designed by computational methods and wind-tunnel tests. This flap, instrumented for pressures and loads, will be flight tested through transonic flight conditions to validate the design procedure by correlation of physical flow characteristics observed in flight versus design predictions. The focus for high angle-of-attack technology validation will be the NASA F-18 High-Alpha Research Vehicle (HARV) being instrumented and prepared for flight tests at NASA-Dryden. This program, involving Ames, Dryden, and LaRC, is concentrating initially on the analysis and prediction of the separated vortex flows generated by the fuselage, forebody, and wing-body strakes at high angles of attack.

W87-70036 **(21) 533-02**
Ames Research Center, Moffett Field, Calif.
HIGH-PERFORMANCE FLIGHT RESEARCH
C. R. Jarvis 805-258-3177
(505-68-00; 533-06-00)

The overall objective is to provide the flight-validated data base required for military and potential civil application of advanced technologies. Program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research and flight research tests. Generic high angle-of-attack research will be initiated with an F-18 test aircraft. Under the joint NASA/USAF Advanced Fighter Technology Integration (AFTI) program, the F-16 automated maneuver attack system development, demonstration, and tactical evaluation will be completed, as will F-111 manually-controlled mission adaptive wing research. Automatic-controlled research will be initiated for the F-111. Highly integrated digital electronic control flight research will be initiated for the F-15 adaptive engine control system phase, investigating the variable engine operating line concept. Develop the technologies necessary to permit V/STOL aircraft to effectively operate in all mission phases and validate these technologies using the YAV-8B Harrier. The X-29 forward swept wing concept

evaluation phase will continue with its data base development and performance assessment for the full flight envelope.

W87-70037 **(22) 533-04**
Lewis Research Center, Cleveland, Ohio.
TURBINE ENGINE HOT SECTION TECHNOLOGY
D. E. Sokolowski 216-433-3216

The overall objective of this effort is to improve durability of combustor liners, turbine vanes, and turbine blades for advanced civil and military aircraft turbine engines by improving life prediction during the design process. Life prediction systems will be made more effective by improving system elements which characterize fundamental behavior. These elements include models for the behavior of materials at high temperatures and under cyclic loading, aerodynamics, heat transfer, and three-dimensional non-linear finite element structural analyses. The effort consists of contract, grant, and in-house research, both analytical and experimental in nature, in six technical disciplines. The analytical activities are those needed by industry and include computerized models, some of which describe the environments and complex thermal and mechanical loadings in combustors and turbines. The experimental activities provide benchmark quality data required to accurately develop the analytical models and to provide limited validation.

W87-70038 **(22) 533-05**
Lewis Research Center, Cleveland, Ohio.
CERAMICS FOR TURBINE ENGINES
S. R. Levine 216-433-3276
(505-63-00; 506-53-00)

The objective of this project is to develop the technology base required to apply structural ceramics to advanced turbine engines. The effort covered by this RTOP is interdisciplinary in nature. It integrates research and technology development in materials/processing, design methodologies and life prediction for both monolithic and ceramic matrix composites. It includes a range of contracts, grants, and in-house research to define and improve the processing variables that control ceramic reliability. The work in the early years of this effort will concentrate on obtaining improved ceramic material properties, and identification of high-temperature ceramic composites. The work in the later years of this effort will focus on evaluation of time dependent properties and maintaining the improved ceramic material properties. The approach to this program will be to systematically study the variables involved in ceramic materials processing, to identify advanced ceramic composites, to apply non-destructive evaluation as a research tool to better understand processing, and, finally, to evaluate material properties both in modules of rupture sized test bars and in larger shapes to demonstrate the scale up potential of the technology. The technology developed under this RTOP will permit the application of ceramic materials to a wide range of aerospace propulsion and power systems.

W87-70039 **(21) 533-06**
Ames Research Center, Moffett Field, Calif.
OBLIQUE WING TECHNOLOGY
M. R. Barber 805-258-3165
(505-66-00)

The concept of an oblique wing aircraft shows promise for efficient subsonic, transonic and supersonic operations. Feasibility studies applying this concept to specific applications have shown that significant reductions in aircraft structural weight can be achieved over designs employing conventional variable sweep wing technology. The objective of this program is the validation of these potential performance and design improvements and the development of baseline oblique wing technology for application to mission oriented aircraft designs. An important step in validating the oblique wing concept is to produce a full scale, manned, test aircraft capable of operating in the transonic and supersonic speed range with subsequent experimental flight testing. The NASA F-8 Digital Fly-by-Wire research aircraft is well suited as a test bed for this program because of its high wing configuration, three-point wing attach arrangement, versatile digital fly-by-wire flight control system, airborne instrumentation system as well as existing Iron-Bird and ground-based simulation facilities. Modifications will reconfigure the aircraft into an oblique wing design.

Advanced Propulsion Systems Technology

W87-70040 **(23) 535-03**
Langley Research Center, Hampton, Va.
ADVANCED TURBOPROP SYSTEMS
C. P. Blankenship 804-865-2042

The objective of the program is to develop both aerodynamic and acoustic technology necessary for the design of future advanced turboprop-powered aircraft. Configurations of interest are powered by highly loaded, multi-bladed, single-rotating, and counter-rotating propeller systems. Emphasis is on prediction and control of propeller aerodynamic interactions and cabin interior noise environments. The approach is to develop improved analytical and experimental methods for predicting aerodynamic flow field interactions, aircraft stability and control characteristics, propeller noise (both in the near field and far field), and airborne and structure-borne noise transmission through the cabin sidewall. These prediction methods are validated using wind-tunnel data and results from a joint NASA/industry flight demonstration program. The improved prediction methods and criteria will be used to guide the design of advanced turboprop propellers and aircraft configurations.

W87-70041 **(21) 535-03**
Ames Research Center, Moffett Field, Calif.
ADVANCED TURBOPROP SYSTEMS
D. P. Bencze 415-694-6618

The work covered by this RTOP is the development of the technology to demonstrate the feasibility of advanced turboprop transport aircraft capable of cruise speeds up to 0.8 Mach number and altitudes above 35,000 feet. Theoretical and experimental studies will be conducted to define the aerodynamic technology required to integrate advanced turboprop propulsion systems with supercritical wings and fuselages. Detailed flow interactions among the propeller slipstream, nacelle, and wing surface will be examined and methods to optimize the installation identified. Theoretical analyses will include linear and non-linear methods capable of handling the transonic slipstream-nacelle-wing interactions. Experimentally, the flow interactions will be measured with powered semi-span wind tunnel models and flight vehicles that provide accurate simulation of the actual flow conditions. A series of full-span, powered models will be built to measure stability and control characteristics and to compare installed thrust efficiencies of single and counter-rotation propfan designs.

W87-70042 **(22) 535-03**
Lewis Research Center, Cleveland, Ohio.
ADVANCED TURBOPROP SYSTEMS
J. A. Ziemianski 216-433-3901

The objective of the Advanced Turboprop Systems effort is to develop and evaluate propeller and related drive system and aircraft technologies critical to the efficient, reliable, and acceptable operation of future advanced, high-speed, turboprop-powered aircraft. Both single- and counter- rotating propeller systems and their technologies are being evaluated. Propfan technologies will be evaluated in ground and flight testing of a large-scale single rotation propfan propulsion system. Ground testing of counter-rotation systems, including a large-scale unique ungeared pusher propeller system and large-scale advanced gearboxes, will also be accomplished. Aerodynamic, acoustic, and mechanical performance will be evaluated.

W87-70043 **(22) 535-05**
Lewis Research Center, Cleveland, Ohio.
GENERAL AVIATION/COMMUTER ENGINE TECHNOLOGY
J. A. Ziemianski 216-433-3901
(505-62-11)

The objective of this effort is to provide the advanced technology base needed to insure the technical advantage of U.S. manufacturers in the future small turbine engine marketplace. The approach is to evolve, evaluate, and verify critical advanced technology applicable to gas turbine engines of 250 to 5,000 shp suitable for general aviation, commuter, rotorcraft, and cruise missile applications. Analytical and experimental studies will emphasize revolutionary powerplant improvements in the 250 to 1,500+ shp range. Program subelements are: (1) system studies; (2) discipline R&T; and (3) component R&T. This overall approach will provide industry with the capability to design and build small engines with performance, reliability, maintainability, and durability approaching that of large engines.

Numerical Aerodynamic Simulation

W87-70044 **(21) 536-01**
Ames Research Center, Moffett Field, Calif.
NUMERICAL AERODYNAMIC SIMULATION (NAS)
F. R. Bailey 415-694-6419
(505-60-00)

The objectives of the NAS program are threefold: to act as the pathfinder in advanced, large-scale computer system capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies; to provide a national computational capability to NASA, DOD, other government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of three elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, and the operation of the NpSN. This RTOP covers the overall management of the program and development of the processing system. It does not cover the facility and operations elements. The NPSN technical approach is one of phased and evolutionary development which will incorporate the latest advancements in scientific supercomputers, graphics devices, storage media and other computer system technologies.

Space Research and Technology Base

Aerothermodynamics Research and Technology

W87-70045 **(23) 506-40**
Langley Research Center, Hampton, Va.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
R. R. Nunamaker 804-865-2893
(506-49-00; 506-48-00)

This research is to improve the fundamental understanding of aerodynamic and aerothermodynamic flow phenomena over ascent and entry vehicles and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Emphasis is on providing flow-field computational capability in the free-molecular, transitional, and continuum flow regimes; providing analytical and turbulence chemistry models; utilizing shuttle wind-tunnel, flight, and analytical prediction data to validate techniques for the design of future vehicles; providing the design and performance parameters on advanced vehicles to identify and analyze high payoff technologies; scoping heating problems on advanced concepts and developing prediction techniques; providing the experimental and analytical data base to improve understanding of the interaction of high-temperature, and Mach number on current and advanced vehicles; and improving wind-tunnel technology, test techniques, and instrumentation for fundamental research. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. Analytical, computational, and experimental techniques are included in the fundamental research conducted in-house, by university grants, and under contract to industry. The experimental portion of the program emphasizes the unique Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel.

W87-70046 **(21) 506-40**
Ames Research Center, Moffett Field, Calif.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(505-60-00; 506-43-00; 763-01-00)

The objective is to advance the fundamental understanding of aerodynamic flow phenomena in hypersonic flight regimes and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Advanced computation methods and computer codes will be developed and validated for numerically simulating vehicle flow fields. The results will then be used to predict thermal loads to, and aerodynamic performance of, the vehicle. The codes will yield solutions for the full Navier-Stokes equations for a chemically reacting and radiating gas. Such developments depend on results of both numerical simulations and experiments for improving and/or validating these complex codes. In addition, engineering models are being developed that will give reasonable approximations of the benchmark results, and may be used for rapid assessment of vehicle performance. Research will be performed leading to on-board laser instrumentation for entering spacecraft that will allow remote optical measurements of local ambient atmosphere and spacecraft flow field properties. Laboratory research will be performed to develop and verify the application of an ultra-violet laser system, on board the shuttle orbiter, for the accurate measurement of ambient density along the flight path during entry. The use of the Shuttle Entry Air Data System (SEADS) will be investigated at subsonic and transonic speeds by the Dryden Flight Research Facility.

Space Energy Conversion Research and Technology

W87-70047 **(23) 506-41**
Langley Research Center, Hampton, Va.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
R. R. Nunamaker 804-865-2893

This program is part of the space energy, power management, and distribution effort. The program contains two research areas, laser space power transmission and advanced concepts. The goal of the laser area is to assess the scientific and technical feasibility of spacecraft-to-spacecraft power transmission for propulsion and for electric power distribution. Direct and indirect solar-pumped lasers are conceived, tested, and modeled. Near-term objectives are to define efficient solar-pumped lasers and to establish scaling laws for estimating high average power operation. In conjunction with laser energy generation, laser-to-electric conversion is a major aspect of laser transmission for electric power distribution. A potentially high efficiency concept being studied is laser photovoltaic conversion. Research on this concept is both experimental and theoretical. To assess the advantages of space power transmission and to guide the laser and converter research, limited trade studies are performed. Advanced concept research is primarily focused on plasma switch experiments. The plasma switch operates in an inverse-pinch mode with the objective of high power, long life operation. The device can either close or open a circuit and research is a combination of experimentation and modeling. Potential applications for this type of switch include pulsed power requirements for advanced electric propulsion in space and for both terrestrial and defense missions.

W87-70048 **(55) 506-41**
Jet Propulsion Laboratory, Pasadena, Calif.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objective is to develop and demonstrate advanced technologies in the areas of solar energy conversion, chemical energy storage, and thermal-to-electric conversion, for spacecraft power systems up to 25kW. Development of high performance light weight solar array technology for spacecraft will enable and demonstrate the capability for systems with 300 W/kg and/or 300 W/sq-meter performance. Research on both primary and rechargeable high energy density spacecraft batteries will continue. Investigations of fundamental cell chemistry, polymer electrolyte cells, high-energy density cathode materials, and Li-SOCl2 cell designs, will be conducted to better understand and characterize the factors which affect life, reliability, and safety. Experimental evaluation of advanced thermoelectric materials will be conducted to quantify their performance for static thermal-to-electric systems application. New materials and innovative processing techniques may produce static thermal-to-electric conversion efficiency near 20%. Analytical models of these materials are also being developed to determine what theoretical limitations prevent achieving even higher efficiencies. Further study of the Alkali Metal Thermoelectric Converter (AMTEC) concept will include experimental testing of electrodes, leading to achievement of greater than 30% conversion efficiency and multi-year lifetime.

W87-70049 **(62) 506-41**
Marshall Space Flight Center, Huntsville, Ala.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
R. T. Bechtel 205-544-3294

The overall objective of this RTOP is to provide the necessary research and development in needed technologies for high-power photovoltaic energy conversion for spacecraft power systems. These efforts will provide the technology for multi-100 kW, low-cost concentrator solar arrays. Concentrator hardware utilizing different concentration techniques will be developed and tested at the module and submodule levels to evaluate and characterize both electrical and thermal performance. A variety of appropriate solar array materials will be involved.

W87-70050 **(51) 506-41**
Goddard Space Flight Center, Greenbelt, Md.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
R. McIntosh 301-286-6071

The objective of this research is to develop, analyze, and test various thermal energy management concepts and components for application to future spacecraft and space structures. The focus is on thermal control of power systems, instrumentation, and other heat dissipation equipment. High temperature and long life applications will be stressed. This work will be accomplished through: (1) basic research into thermo-fluid mechanical phenomena under micro and partial gravity; (2) development and test of various two-phase components and systems; (3) development of analytical models for performance prediction and test verification; (4) development of and integrated mounting plate for thermal, power, and data utilities; and 5) small flight experiments.

W87-70051 **(22) 506-41**
Lewis Research Center, Cleveland, Ohio.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
H. W. Brandhorst 216-433-6149

The objective of this work is to provide a research and technology development base leading to a spectrum of advanced space power systems and subsystems. Areas include photovoltaics, electrochemical energy storage, power management and distribution, components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, thermal and solar dynamic systems, advanced radiator concepts, two phase flow in zero-G, and supporting technology for the SP-100 nuclear power system, focussing on free-piston Stirling engines. Major thrusts are to improve performance, reliability, and tolerance to the plasma and radiation environment, while reducing cost and mass where appropriate, for systems operating in the LEO, GEO and planetary environments. The research generally aims at providing the technological base for emerging multihundred kilowatt to megawatt level power system needs, while also recognizing and addressing commercial needs up to the 10 kilowatt level.

W87-70052 **(72) 506-41**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
W. W. Guy 713-483-4931

The objectives of this RTOP are to develop the thermal management and crew life support systems technologies which will enable an orderly growth in both system size and capability for future manned missions in space (e.g., growth space station, geo platform, lunar base, planetary). The tasks included in the RTOP for thermal management are directed at the development of critical technologies in the heat collection, transport and rejection areas and associated analysis techniques. More efficient and effective heat pipe technology will be developed, advanced radiator concepts assessed, and thermal bus design limitations will be addressed through breadboard system evaluation. Additionally, transient thermal management analysis techniques involving heat pipe, chemical heat pump, and two-phase fluid flow will be developed to support these technology developments as well as provide tools for future missions that incorporate the newly developed technology. The tasks included in this RTOP for crew support are directed at improving process efficiencies, reducing expendables, and attaining a higher degree of system closure. Particular emphasis will be placed on the development of advanced processes to accomplish the functions of air revitalization, water recovery, and waste management.

W87-70053 **(10) 506-41**
National Aeronautics and Space Administration, Washington, D.C.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Edward Gabris 202-453-2847

The purpose of this RTOP is to provide support to the Headquarters operation of the Office of Aeronautics and Space Technology Space Energy Conversion Program. This will include: (1) operation of the multi-agency supported Power Information Center of the Interagency Advanced Power Group; (2) support to the SP-100 Missions Advisory Panel; (3) analytical efforts in support of Space energy conversion technologies; and (4) support of specialists' meetings and conferences in space energy conversion and aero/life support disciplines.

Propulsion Research and Technology

W87-70054 **(55) 506-42**
Jet Propulsion Laboratory, Pasadena, Calif.
PROPULSION RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objective is to study advanced propulsion system concepts in order to identify critical technology development requirements, and also to develop and demonstrate feasibility for the most promising concepts. Studies and laboratory experiments have initially shown the feasibility of ion, electrothermal arcjet, and Magneto Plasma Dynamic (MPD) propulsion concepts. Efforts in the coming year will focus both on fundamental research to identify and model the basic physics of operation, and on development of critical components such as high current cathodes, new fuels, and new steady state operating MPD thrusters. These developments will lead to a technology readiness for mission application in the 1990's. For the more ambitious missions of the 21st century, studies will be carried out to identify propulsion concepts which

offer substantial performance increases. Study candidates include nuclear fission or fusion, beamed microwave or laser energy, solar sails, and anti-proton annihilation. These studies will examine feasibility issues, define critical technology development requirements, and proof-of-concept experiments that are required both to evaluate these advanced concepts, and to guide future technology development programs.

W87-70055 **(62) 506-42**
Marshall Space Flight Center, Huntsville, Ala.
PROPULSION RESEARCH AND TECHNOLOGY
R. J. Richmond 205-544-4935

The overall objective of this effort is to extend and further develop the propulsion technology base in support of the current and future space transportation systems. Technology for advanced, reusable main propulsion for earth-to-orbit and orbit-to-orbit application is being pursued. Earth-to-orbit technology encompasses both oxygen/hydrogen and oxygen/hydrocarbon propulsion and is directed at enhancing engine life, performance and operability. The activities include analytical model development, performance improvement, cold flow testing, combustor cooling, uniform temperature turbine drive gas generation, control system analysis, materials and process synthesis and advanced instrumentation development. The oxygen/hydrogen propulsion technology activities for orbit-to-orbit application include investigation of high area ratio nozzle concepts, materials and construction techniques, and enhancement of performance prediction models.

W87-70056 **(22) 506-42**
Lewis Research Center, Cleveland, Ohio.
PROPULSION RESEARCH AND TECHNOLOGY
D. A. Petrash 216-433-2439

The purpose of this RTOP is to provide the technology base for all types of primary and auxiliary space propulsion systems. Included are future reusable hydrogen/oxygen and high-density/oxygen earth-to-orbit propulsion systems; advanced space-based orbit-to-orbit propulsion systems; long-life high performance auxiliary propulsion systems; high Isp spacecraft primary propulsion systems; and advanced propulsion concepts.

W87-70057 **(10) 506-42**
National Aeronautics and Space Administration, Washington, D.C.
PROPULSION RESEARCH AND TECHNOLOGY
Edward Gabris 202-453-2847

The primary objective of this activity is to maintain a continuous up-to-date information gathering capability on the nation's total chemical propulsion technology efforts as an aid in planning and implementing the NASA program. In addition, joint interagency tasks are undertaken when appropriate, such as publishing handbooks, manuals, or computer models, that will be beneficial to the propulsion community as well as other potential users. The approach is to share support of the Chemical Propulsion Information Agency (CPIA), which supplies information gathering and dissemination services, with DOD agencies through the Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Propulsion Committee. For special interagency tasks, funding is transferred to the agency designated as responsible for the procurement action and contract monitoring.

Materials and Structures Research and Technology

W87-70058 **(23) 506-43**
Langley Research Center, Hampton, Va.
MATERIALS AND STRUCTURES REASEARCH AND TECHNOLOGY
C. P. Blankenship 804-865-2042

The research includes executing analytical and experimental programs in structures and materials with emphasis on: (1) thermal structures and aerothermal effects; (2) structural dynamics and concepts; (3) polymeric materials, metallic materials, and composite materials; and (4) inter-disciplinary analysis and optimization. The objective is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. The experimental portion of the program emphasizes laboratory experiments which utilize Structures Directorate unique resources which include testing facilities and highly trained personnel.

W87-70059 **(55) 506-43**
Jet Propulsion Laboratory, Pasadena, Calif.
MATERIALS AND STRUCTURE RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objective is to develop advanced materials and structures technology for use in future space systems. Analytical and experimental research will be conducted to investigate new methods for predicting the chemical, physical, and mechanical properties and reactions of spacecraft materials such as polymers, composite matrices, alloys, and heat shields. Greater understanding of the correlation between molecular parameters and observed mechanical properties will lead to a capability for producing very specific mechanical characteristics by utilizing innovative molecular designs. Development will continue on the design optimization methodology for fabricating lightweight, thermally stable, very high surface precision reflector panels for in-space optical systems. In the area of space environmental effects, beams of energetic oxygen atoms, charged particles, and short wavelength UV light, will be used along with spectroscopic and analytical techniques, to characterize the degradation processes of polymers in a simulated space environment. These experiments will determine the long term effects of the space environment on candidate spacecraft materials. Research on flexible structure dynamics will both develop new methods, and improve existing methods, for the analysis and synthesis of large complex structural systems. The limitations of ground testing very large flexible structures will also be investigated.

W87-70060 **(51) 506-43**
Goddard Space Flight Center, Greenbelt, Md.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
M. Fitzmaurice 301-286-9842

The overall objective of this plan is to develop and verify contamination models leading to improved prediction capability, new materials and protective methods. The current plans for this research are to develop and fly instrumentation to characterize on-orbit environments, develop ground based facilities for material characterization, develop a data base, improve, develop and verify models, advance material development, and develop protective and collection devices.

W87-70061 **(10) 506-43**
National Aeronautics and Space Administration, Washington, D.C.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Samuel L. Venneri 202-453-2760

The objective of this RTOP is to develop a wide range of analytical tools and experimental techniques for use in the design, development, and analysis of the structures and structural dynamics of complex spacecraft and space structures. The program will be structured to foster innovative engineering solutions and design concepts for such vehicles. A number of key structural integrity issues will be addressed in order to develop the understanding and tools needed for the next generation of space structural design concepts.

W87-70062 **(21) 506-43**
Ames Research Center, Moffett Field, Calif.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(763-00-00; 506-44-00)

The objective is to provide advanced materials technology for the development of future space systems with significant improvements in performance, durability and economy. Emphasis is given to computational materials science and thermal protection materials development. In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These and extrapolations to larger systems are being studied to compare with experiment and to obtain surface and bulk properties. These results are used to study chemisorption, catalysis, corrosion and the physical properties of polymers. Ames' unique arc-plasma test facilities, ceramic materials laboratory, and analytical and computational capabilities are used to develop materials and optimized systems for advanced space transportation vehicles, enhanced space shuttle vehicles, aeroassisted orbital transfer vehicles (AOTV), transatmospheric vehicles (TAV), planetary and solar probes, and safe earth reentry of radioactive power sources. Candidate thermal protection system (TPS) concepts and materials are selected and subjected to systematic analysis and testing to qualify for defined end use. At the Dryden Research Facility, advanced predictive methods for properties of structures will be validated and concepts demonstrated.

W87-70063 **(22) 506-43**
Lewis Research Center, Cleveland, Ohio.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3190

The objectives of this RTOP are to develop greater understanding of materials with aerospace propulsion and power potential and to develop guidelines for improving their physical/mechanical properties and reliability. Fundamental studies are aimed at investigating mechanical and other factors that limit material reliability, performance, and useful life. Fundamental studies are also aimed at identifying scientific concepts that might be applied to substantially improve aerospace materials. The research includes: (1) material properties/performance enhancement via innovative application of nondestructive evaluation concepts/models for characterization of microstructure and mechanical properties; (2) understanding the basics of friction, wear, adhesion, thin film liquid lubrication, and the chemistry and morphology of solid lubricants; (3) work to develop ceramic matrix composites for aerospace applications; and (4) development of materials for heat storage and space power applications. The analytical and experimental results of this RTOP will have far reaching practical applications for a wide range of aerospace materials, structures, and components.

W87-70064 **(72) 506-43**
Lyndon B. Johnson Space Center, Houston, Tex.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Lubert J. Leger 713-483-2059

The objectives of this RTOP are to: (1) conduct ground-based simulation of atomic oxygen effects on materials, coatings and lightweight flexible structures for potential use on space station and (2) examine the effects of hypervelocity impacts from meteoroids and orbital debris on composites. An atomic oxygen facility at Los Alamos National Laboratory will be used to conduct studies within a simulated orbital environment and investigate the effects of extended exposure (10e22 to 10e23 atoms/cme2) on a limited number of space station materials, with the results of these investigations to be verified later during the EOIM-3 oxygen effects experiment when it is assigned to an STS mission. The examination of the hypervelocity impact resistance of composites will be carried out in the orbital debris impact laboratory using massive projectiles of varying densities, with the data to be incorporated into refining the present mathematical model.

Space Data and Communications Research and Technology

W87-70065 **(23) 506-44**
Langley Research Center, Hampton, Va.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915
(506-45-00)

The objective is to research new concepts in space data and communications. This concept development will result in planning, development, and delivery of technology research and development studies, system feasibility models, and prototype proof of concept hardware in support of NASA's mission, including advanced Aerospace Transportation Vehicles, Space Station, Co-orbiting Platforms, and Deep Space Payloads, in the areas of Data Systems and Communications. The approach is to use mission identified needs, together with new device and systems technologies in high-speed, space qualified processors, storage, antenna concepts, and analyses together with concepts and components for optical communications to given enabling and enhanced system level performance. In particular, elements will be researched and developed through the proof of concept phase, and this technology will be delivered to mission projects where appropriate. Individual tasks included are VHSIC processor technology, phased array semiconductor lasers, distributed feedback semiconductors lasers, multibeam feeds for LaRC and spaceborne antennas, and millimeter wave technology.

W87-70066 **(55) 506-44**
Jet Propulsion Laboratory, Pasadena, Calif.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
David A. Nichols 818-354-8912

The objective and approach of this RTOP is to provide the necessary research and technology development of space data and communication systems to: develop high-performance adaptable fault-tolerant flight computers for applications in NASA missions; develop strategies and architectures for on-board processing components in support of extremely high rate imaging sensors; develop technology for next generation deep space and near earth communications; experimentally evaluate several optical communications component technologies; develop high power and power-efficient laser array concepts for use as free space optical communications sources; and develop analysis and software techniques necessary for designing and predicting RF performance of advanced antenna systems, antenna feeds for multiple-beam applications, and ground and in-flight RF measurement techniques for large spaceborne antennas.

W87-70067 **(51) 506-44**
Goddard Space Flight Center, Greenbelt, Md.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. Dalton 301-286-8623

Develop and demonstrate the systems technology to substantially increase the capability of on-board data systems in response to requirements for future NASA missions. Specific objectives are to: (1) define methodologies for the assessment of alternative data system architectures; and (2) advance the state-of-the-art in on-board processing through the application of Gallium Arsenide integrated circuit technology

W87-70068 **(21) 506-44**
Ames Research Center, Moffett Field, Calif.
SPACE DATA COMMUNICATIONS RESEARCH AND TECHNOLOGY
T. L. Grant 415-694-6526
(482-55-00; 549-00-00)

The objective is to advance the state-of-the-art in distributed processing communications technology through analysis of general concepts and the implementation of software simulation to define, develop and evaluate detailed concepts. The emphasis in this technology development is both on reduced system complexity for data networks and on increased reliability, while providing the flexibility to expand data capacity as processing requirements increase. The development of network concept and protocol models primarily uses the Ames Research Center computational facilities. It provides a common tool for developing and evaluating detailed designs in coordination with other Centers as well as augmenting and validating the theoretic analysis of general concepts.

W87-70069 **(22) 506-44**
Lewis Research Center, Cleveland, Ohio.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Denis J. Connolly 216-433-3503
(506-44-00)

The overall objective of this RTOP is to provide through research, design and experimental tests, the components, subsystems and enabling technology required to support NASA satellite communications systems. To achieve this objective, advanced research and development programs will be conducted to identify, produce and demonstrate critical components, techniques and subsystems required for complete communications systems. Principal emphasis will be directed toward spacecraft microwave electron beam amplifiers with increased power output, linearity, efficiency, high frequency capability and long life; multi-frequency, multi-beam antennas providing increased frequency reuse at higher frequencies; and solid state materials and component technology for high frequency spacecraft applications, such as switching, power amplification and beam forming.

W87-70070 **(10) 506-44**
National Aeronautics and Space Administration, Washington, D.C.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Lee B. Holcomb 202-453-2747

The purpose of this RTOP is to develop an erasable optical disk buffer device capable of storing and retrieving up to I terabit of information at rates up to !.6 gigabits/second. Laser/optical disk technology will be employed in concert with advanced laser diode arrays to achieve high performance. This is a technology feasibility demonstration in cooperation with other government agencies. This unit has main applications to supercomputers and the space station data system.

W87-70071 **(72) 506-44**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
S. A. Gorman 713-483-2757
(506-44-11)

This proposal will establish a NASA sponsored Software Engineering Research Center at the High Technologies Laboratory of the University of Houston at Clear Lake (UHCL). The center will provide a means of focusing NASA research into software engineering issues and will also provide a formal liaison with other similar centers of research such as the Defense Department's Software Engineering Institute (SEI) at Carnegie Mellon University. Areas of research will include: new techniques in software lifecycle management; productivity tools for software development and maintenance; development and maintenance of distributed information systems; NASA software engineering training requirements; advancements in operating systems and network operating systems; advancements in computer networks; use of the ADA language and associated environments on NASA projects; application of expert systems and artificial intelligence techniques to lifecycle management; others as directed by NASA.

Information Sciences Research and Technology

W87-70072 **(23) 506-45**
Langley Research Center, Hampton, Va.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
W. D. Mace 804-865-3745

The objective of this program is to develop all solid state components for versatile active remote sensors supporting high-flying aircraft and spacebased earth science investigations in atmospheric dynamics and chemistry. The most important of these sensors are light detection and ranging (lidar) and differential absorption lidar (DIAL) systems. This research and technology program has been structured to approach these challenges in the areas of laser materials research, laser transmitter design and development, lifetime and efficiency improvement, and detector research.

W87-70073 **(55) 506-45**
Jet Propulsion Laboratory, Pasadena, Calif.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Aurthur Murphy 818-354-6457

The objective of this work is to advance the fundamental principles which form the basis of the sensing, use, and management of space-derived information; and to expand the applications of advanced information sciences in space. A complementary set of objectives is to provide an agency-wide foundation in fundamental aerospace computer science, to facilitate the infusion of state-of-the-art computing technology into aerospace applications, and finally to advance optical processing technology to augment NASA mission capabilities and the national interest. The approach in the passive and active remote sensing element of this work is to maintain parallel device research and device development activities in the following primary areas of the electromagnetic spectrum: first, the submillimeter regime; second, the near infrared application of charge coupled devices; and third, a semi-conductor laser development activity aimed at in-situ sensing while supporting active remote sensing solid state laser device pumping development. In addition, the approach will continue to investigate solid-state materials and concepts and to design, develop and test devices and components for: (1) passive sensing utilizing either coherent or incoherent detection methods, (2) detection devices and systems for use in the submillimeter portion of the electromagnetic spectrum, and (3) active sensing utilizing coherent sources.

W87-70074 **(10) 506-45**
National Aeronautics and Space Administration, Washington, D.C.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Lee B. Holcomb 202-453-2747
(505-37-10)

This RTOP provides support for aerospace computer science university research and an Advisory Group on Electron Devices (AGED). The objectives are to: (1) develop a university-based center for aerospace computing technology, focusing on concurrent processing, highly reliable computing, and scientific and engineering information management; (2) foster cooperative, coordinated research coupling computer science with aeronautics, astronautics, and space sciences; and (3) provide, through AGED, effective coordination of NASA-sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on AGED and its constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R&D procurement activities, long-range R&D

requirement, complementary work in other government agencies, and forecasts of new technical developments.

W87-70075 **(21) 506-45**
Ames Research Center, Moffett Field, Calif.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
C. R. McCreight 415-694-6549
(506-44-00; 482-58-00; 549-01-00)

One objective of this RTOP is to develop technologies in artificial intelligence and information sciences leading to an image-based advanced machine intelligent system for spaceborne applications. Emphasis is in the areas of spaceborne optical and symbolic processing architectures, information understanding, knowledge acquisition and representation, programming environment, and natural languages/interfaces. A cooperative Ames-academia-industry team consisting of world-class researchers has been established to conduct the required research with memoranda-of-understanding established with project centers to transfer the technologies to project applications. A second objective is to develop advanced infrared detector array technology and supporting cryogenic systems for future astronomical applications. The array technology is applicable to low- and moderate-background astronomical applications throughout the infrared (IR) spectrum (2-200 micrometers) and will directly benefit programs such as Space Infrared Telescope Facility (SIRTF) and Large Deployable Reflector (LDR). Development of on-orbit liquid helium (LHe) resupply, efficient long-term space storage techniques, and advanced coolers for less than 1 kelvin operation are elements of the cryogenics program. These activities blend analysis with component development, and include extensive in-house characterization and selected technology demonstrations.

W87-70076 **(22) 506-45**
Lewis Research Center, Cleveland, Ohio.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Denis J. Connolly 216-433-3503
(506-44-00)

The objective of this RTOP is to provide through research, design data and developments of materials and methods, the technology base for the development of voltage tunable local oscillator sources, capable of approximately 1 milliwatt output in the frequency range between 600 to 2000 GHz. The approach taken pursues the development of voltage tunable, electron beam excited backward wave oscillators, with an expected frequency tuning range (by voltage tuning) of approximately 10 percent above and below a center frequency. Because of the extreme smallness of slow wave structure dimensions (less than 50 microns) new methods of fabricating BWO circuits must be explored. These include reactive ion etching, laser cutting and metallization techniques. In addition, skin effect losses and direct interception will necessitate novel approaches for heat rejection. Also, for these micron size circuits, the technology for very small electron beams of densities around 1000 A/cm2 will be developed.

W87-70077 **(72) 506-45**
Lyndon B. Johnson Space Center, Houston, Tex.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
C. D. Sykes 713-483-4901

This proposal will continue a HAL/S language definition and user group, also referred to as the NASA HAL/S board. The board was established in 1977 to provide language support for the standard HAL/S compiler, tools, and documentation. This support will (1) maintain the standard compiler and documentation by providing a secretarial function for the board, (2) control change requests and discrepancy reports by providing compiler maintenance/documentation, and (3) improve user tools and interfaces to maintain compiler viability evolving environments by developing tool improvements and special studies as approved by the NASA HAL/S board. FY87 tasks include completion of studies and upgrades begun in FY 86, and development of improved user interfaces.

W87-70078 **(51) 506-45**
Goddard Space Flight Center, Greenbelt, Md.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
H. Plotkin 301-286-6185

The RTOP includes fundamental and applied research in computer sciences and sensor technology for remote scientific observations -- a total of 10 tasks. The research in computer science objectives are (1) to study and implement systems to handle very large multi-source data bases managed at distributed locations; (2) to develop and evaluate software management tools, software design metrics, and approaches to rapid prototyping; and (3) to develop concurrent processing algorithms critical to space research and data analysis.

Controls and Guidance Research and Technology

W87-70079 **(23) 506-46**
Langley Research Center, Hampton, Va.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-865-4915

To provide fundamental and applied guidance, navigation, and control (GN&C) research and technology for advanced spacecraft, space platforms, and transportation vehicles. Major activities are to advance the state of the art in control of large flexible space structures through development of modern control theories, advanced sensors and actuators and optimize payload science returns by incorporating advanced technology concepts for isolation and high-accuracy pointing. Advanced G&N concepts are under study for advanced space transportation system elements and orbital return and planetary entry vehicles using aerodynamic deceleration. Advanced control and modeling techniques and on-line identification will be utilized with dynamics models of such spacecraft as a manned space station, shuttle-attached experiments, large diameter antennae, advanced space transportation system concepts, and reentry vehicles. Resulting GN&C system implementations will be thoroughly evaluated. Analytical efforts will be complemented by ground validation on such test articles as the LaRC grid, SCOLE, and by flight experiments, such as in conjunction with the Control of Flexible Structures Program and Aero-Assisted Flight Experiment to quantify the effectiveness of the various candidate GN&C techniques.

W87-70080 **(55) 506-46**
Jet Propulsion Laboratory, Pasadena, Calif.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objectives are to develop and evaluate advanced control and guidance concepts, designs, algorithms, and components required for the autonomous control, pointing, guidance, and stabilization of future space systems including large space antennas, the evolutionary space station, orbit transfer vehicles, and advanced earth orbiters and planetary spacecraft. The approach for achieving these objectives will be to: (1) Develop and validate system identification techniques and software for automated monitoring of system performance; synthesize adaptive control designs for autonomous compensation of dynamic uncertainties and/or configuration change; and continue development of unified controls/structure modeling and design methodology for improved robustness. (2) Develop two advanced guidance and control components: FORS, a long life all solid state integrated optics fiber gyro, and SHAPES, a 3-dimensional position optical sensor for static and dynamic figure measurement and dynamic identification of flexible spacecraft and large antennas. (3) Develop and evaluate micron accuracy measurement concepts and technologies suitable for use in control of future segmented large optical space systems. (4) Develop and validate technologies for an actively controlled softmount interface for precision payload pointing. (5) Develop and validate controls and guidance concepts for future aeromaneuvering spacecraft.

W87-70081 **(62) 506-46**
Marshall Space Flight Center, Huntsville, Ala.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
H. J. Buchanan 205-544-1470

The overall objective of this research is to define, develop, and demonstrate advanced control concepts for the stabilization and control of future spacecraft, payload pointing systems, and advanced transportation vehicles. The work is focused in two primary areas: The stabilization and control of large flexible structures in space and advanced control techniques for the next generation of space transportation vehicles. In the first area, the effort will be a continuation of the ongoing analytical and experimental investigation of flexible body control techniques. Here, the principal end product will be new control techniques for pointing, slewing, and actively rigidizing large systems in space. The second area represents an expansion in scope to address improvements in vehicle control design practice which will result in reduced transportation system operational cost and at the same time enhance system reliability and utility.

W87-70082 **(72) 506-46**
Lyndon B. Johnson Space Center, Houston, Tex.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
K. J. Cox 713-483-4281
(505-66-00)

The objective is to develop and assess guidance, navigation, and control concepts, techniques, and design methodologies to provide needed capabilities for the full and cost-effective utilization of current and future space systems. Methodologies for the cost-effective development and implementation of control capabilities will also be evaluated. Technology needs will be addressed across interacting space fleet elements, including the shuttle, OMV, OTV, MMU, free-flyers, and space station. Studies will be directed toward technology developments which have the broadest application to these fleet elements and which integrate the requirements and constraints associated with the interactions of these elements. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. This activity will also involve the development and demonstration of a system architecture and associated design and evaluation methodologies which will effectively serve the need for advanced information processing across a broad spectrum of future NASA missions. The approach used will be to conduct studies, analyses, and trade-off studies to define hardware and software requirements.

Human Factors Research and Technology

W87-70083 **(21) 506-47**
Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
D. C. Nagel 415-694-5729
(199-22-00; 505-67-00)

Relative to previous space missions, the International Space Station will involve more autonomous operation to minimize the costs of expensive ground support, will incorporate increased automation of on-board systems for greater productivity, will house and support a more heterogeneous crew, and will utilize EVA on a routine and operational basis. To ensure high levels of productivity and operational safety for future space missions such as the Space Station, research will be conducted in two specific areas: crew station design and extravehicular activities. The objectives are to develop a technology base for intelligent operator interfaces to autonomous and supervised systems and to develop a new generation of high performance space suits, gloves, and end effectors that meet the requirements of the Space Station and other manned space missions. In-house and contracted research will be conducted in laboratories and in mission-oriented simulators to provide the technology base. Demonstrations of operator interface technology will be conducted in engineering test beds at other NASA Centers. Finally, advanced suits and other EVA hardware will be developed and tested to provide proofs of concept.

W87-70084 **(72) 506-47**
Lyndon B. Johnson Space Center, Houston, Tex.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. W. Brown 713-483-2291

The objectives of this RTOP are to develop technologies for increasing the productivity, efficiency, effectiveness, and safety of man-systems interactions in spaceflight, and to advance the fundamental understanding of human interaction with increasingly complex and automated systems. The major tasks within this RTOP include development of guidelines for man-machine interfaces, development of models and developing sophisticated means for data collection, developing a technology base of human interfaces with artificial intelligence, and development of new technology crew interface and performance aids for the extravehicular astronaut. To complement the basic research performed under this RTOP, the approach emphasizes the transfer of technologies developed from the research activities to a state that permits applications to ongoing programs. This work will include use of various existing NASA facilities for in house efforts and will include university involvement in developing analytical models of motion.

Space Flight Research and Technology

W87-70085 **(23) 506-48**
Langley Research Center, Hampton, Va.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. R. Nunamaker 804-865-2893
(506-40-00)

The overall objective of this research is to advance the technology for future space transportation systems by providing the necessary data obtained in the correct space environment through the use of experimental flight programs. The approach is to (1) develop and fly experiments which will use the repeated shuttle orbiter entries in order to obtain data which can be used to improve our ability to extrapolate ground-based data and predictions to an actual entry environment, and (2) develop and fly experiments which utilize the shuttle orbiter as a test bed in orbit so as to improve our understanding of the orbital environment and the performance of transportation systems or space structures in that environment. The results of this research will permit significant advances in our capabilities to design future space systems by greatly expanding the data base of flight data, particularly for the technologies that cannot be fully simulated in ground facilities. Also, new technology will be developed and demonstrated to permit the design of advanced in-space instrumentation and measurement systems.

W87-70086 **(21) 506-48**
Ames Research Center, Moffett Field, Calif.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. O. Arnold 415-694-5265
(506-40-00; 506-43-00)

The objective is to utilize the space shuttle as a flight research facility to obtain data to support and augment the research and technology base for advanced space transportation systems. A better understanding of thermal protection system (TPS) performance during orbiter entry will allow creation of options for TPS cost and weight reductions and improved TPS temperature and durability capabilities for the current space shuttle and advanced aerospace/ hypersonic vehicles. Three separate experiments will be flown as test panels or tiles replacing baseline TPS on the orbiter during operational flights. These experiments take advantage of the actual entry heating environment that cannot be fully simulated in ground facilities. The experiments will investigate TPS convective heating effects and will demonstrate advanced TPS materials for possible orbiter retrofit and for application to advanced vehicles. Baseline TPS procedures and instrumentation will be used to the maximum extent practical. There will be no impact on orbiter operations. These experiments will be designed, developed, and fabricated through both in-house and contract efforts.

W87-70087 **(22) 506-48**
Lewis Research Center, Cleveland, Ohio.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
E. P. Symons 216-433-2853

The overall objective of this RTOP is to provide for the flight verification and evaluation of advanced technologies for future space systems. This part of the Space Flight R&T program is focused on providing an adequate technology base to enable the design of efficient and effective systems for the management of subcritical cryogenic fluids in the space environment including storage, acquisition (positioning) and fluid transfer and achieving technology readiness and user acceptance of a high performance long life ion auxiliary propulsion system. The overall approach involves performing in-space experimentation to obtain data which can be used to verify analytical models or provide demonstrations of technology readiness.

W87-70088 **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. L. Spann 713-483-3617

The objective of the OEX program is to collect data in the technology disciplines that will augment the research and technology base for future spacecraft design. Flight data relative to these disciplines will be collected by utilizing the currently planned AIP/MADS configuration, by modifications and/or augmentations to the DFI base-line instrumentation and development of unique experiments compatible with the operational capabilities for flight on the orbiter. Studies will be conducted to determine the optimum method of utilizing the shuttle system to conduct research and technology. These studies will be augmented by investigation to develop experimental programs that would obtain research and technology data in flight regimes applicable to advanced space transportation systems. The primary goal of these studies is more efficient utilization of the STS capabilities to obtain data required to advance the current state of spacecraft technology. This RTOP includes the effort associated with overall project management, project support, experiment development initiation, experiment compatibility assessments, experiment integration activities and integration hardware development initiation. The experiment development efforts are the subject of additional RTOPs from the appropriate NASA centers.

W87-70089 **(55) 506-48**
Jet Propulsion Laboratory, Pasadena, Calif.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
Richard Key 818-354-3060

The objective is to provide institutional support for the solicitation, award, and management oversight of the technology flight experiment definition study contracts to be awarded to various university and industry principal investigators, within one or more Office of Aeronautics and Space Technology (OAST) defined technology theme areas. In addition, this effort will support periodic technology theme working group meetings at Jet Propulsion Laboratory (JPL) and elsewhere, as well as the production task documentation for program planning purposes. Funding to cover institutional costs is required in order for JPL to support the development of the OAST program and to manage those university and industry contracts which are issued through JPL as a technology theme center.

Systems Analysis

W87-70090 **(23) 506-49**
Langley Research Center, Hampton, Va.
SYSTEM ANALYSIS
R. R. Nunamaker 804-865-2893

The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support conceptual design and development of future spacecraft, advanced earth- and space-based transportation vehicles and large space antennas, platforms, space stations and lunar bases via system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational and experimental facilities will be utilized to accomplish these objectives. Computer-aided engineering, design, and simulation capabilities will be expanded to meet the analysis and technology assessment needs.

W87-70091 **(55) 506-49**
Jet Propulsion Laboratory, Pasadena, Calif.
SYSTEMS ANALYSIS
Richard W. Key 818-354-3060

The objective is to identify critical technology needs for future high priority NASA missions, and assist in the formation of the necessary supporting technology development programs. Studies will focus on two technically demanding missions requiring new and enabling technologies: Mars Sample/Collection Return and the Large Deployable Reflector (LDR) astrophysics mission. Trade studies will be conducted to quantitatively define mission/ technology options. Analytical models will be used to assess various concepts and mechanization schemes. To ensure the achievement of greatest scientific return and maximum cost effectiveness, technological approaches will be carefully evaluated in terms of capability, performance, risk, and cost. Resulting information on the benefits, costs, and development plans/ schedules for each of the technologies considered, will be provided to mission (OSSA) and technology (OAST) program managers to maximize the effectiveness and coordination of their respective programs.

W87-70092 **(51) 506-49**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS ANALYSIS
Philip A. Studer 301-286-5229

The objective of this program is the identification and coordination of technological advances to enhance earth observing missions. Both the polar orbiting platform and geostationary platform requirements are studied to evaluate technology needs. Instrument and spacecraft systems interactions and impact on precision pointing are a prime focus. Another is autonomous system technology with emphasis on control actuators and long-life high performance mechanisms. The approach includes intercenter technology working group activities and a multidisciplinary intercenter group with support from universities and industry. Analyses and evaluation of technology issues, approaches, and system benefits are performed. Plans to initiate and augment technological developments are prepared. On-orbit alignment measurement and control employing both active and passive control for dynamically stable platforms for science and imaging are being studied. Advanced actuators and control mechanizations with lifetime enhancing features are included.

W87-70093 **(62) 506-49**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEMS ANALYSIS
R. F. Nixon 205-544-5033

The objectives of this effort are to conduct trades to identify the technology, benefit analyses to show technology rationale, and planning analyses to outline the resolution of technologies for advanced launch and space vehicles. The result/products of the effort are trades showing performance; benefit analyses showing life cycle cost, leverage, rate of return on investment and risks; and planning analyses showing the approach, facility needs, costs, and schedules for resolving the technologies selected. The approach is to select candidate vehicles/technology areas requiring appropriate technology improvements. Then, determine candidate trade/ technology options within these areas promising an appropriate return for technology investment. Next, conduct these trades to show the specific performance improvements and net investment returns. Finally, make a selection

of the preferred technologies showing the highest returns on investment with the lowest risk and define the plan for resolving these technologies.

W87-70094 **(21) 506-49**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSIS
W. Brooks 415-694-6547
(506-43-00; 506-45-00; 159-41-00)

The objective is to identify critical system and subsystem technology requirements associated with future astrophysics payloads such as the Large Deployable Reflector, the Space Infrared Telescope Facility, and second generation instruments for missions like the Hubble Space Telescope and Advanced X-ray Astrophysics Facilities. The technical complexity of these facilities and instruments, the need for assembly and refurbishment at the space station and the extended lifetime of these missions (10 to 20 years) all represent major areas of uncertainty in system planning and design. Many of the large Astrophysics spacecraft planned for the next 10 to 20 years will be so large that ground system tests will not be possible. Work will continue on the integration of the unique design tools required for telescope and instrument simulation. The work is divided into four principle areas. The first area will be a study of the designs and technologies required to allow space station based replacement and refurbishment of cryogenic instruments. The second effort will involve the study of the long term effects of the space environment on detectors and sensors. The third area will involve the integration of telescope unique design tools. The fourth effort will consist of the definition of a flight program which can be used to demonstrate technology developed in the first three efforts.

W87-70095 **(22) 506-49**
Lewis Research Center, Cleveland, Ohio.
SYSTEMS ANALYSIS
H. W. Brandhorst 216-433-6149

The objective of this RTOP is to identify, assess, and prioritize high leverage spacecraft technologies for NASA and commercial satellites of the late 1990's. For technologies appropriate for further development, as part of the SPACECRAFT 2000 program, long range program plans will be formulated. The goal is, also, to define and develop system level technology requirements for advanced power systems applicable to space stations and lunar missions. The approach consists of: liaison with industry and in-house and contracted studies in the spacecraft bus and communication satellite areas to identify technologies with significant benefits; preparing for the SPACECRAFT 2000 initiative; to define and develop system technology requirements for advanced power systems; and to evaluate the impact on space station and lunar missions. These studies will be used to develop power systems requirements databases and identify high payoff technologies; and to develop/implement plans and strategies for the utilization of an operational space station as an R&T facility for NASA, DOD, industry and academia. Unique facilities, equipment/ instrumentation will be identified. Precursor shuttle experiments to develop technologies will be defined.

W87-70096 **(10) 506-49**
National Aeronautics and Space Administration, Washington, D.C.
SYSTEMS ANALYSIS
Leonard A. Harris 202-453-2733

The objective of this RTOP is to provide space program studies in support of Office of Aeronautics and Space Technology (OAST) space technology program requirements, assessments, planning, and advocacy. The studies are intended to provide an analytical basis for planning activities in space R&T. Areas of work will include: technology status and trends assessments; mission concepts and systems; long-range planning activities; program technology needs, requirements, and opportunities. A major focus of this activity is the NASA Space Systems Technology Model, including its continual update and maintenance. Activity will also include other study contracts, university grants, and consulting services in support of advanced system concepts and policy analysis issues such as those relating to CSTI and potential new or changing roles for OAST in Space R&T.

W87-70097 **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEM ANALYSIS
C. Teixeira 713-483-4478

A primary objective of this task is the development of systems requirements and conceptual designs of space vehicle(s) that are required from earth to orbit, orbital transfer, or lunar descent and/or ascent and the definition of the associated operational requirements. This study will incorporate the data base developed by previous studies on this subject, which will allow a more indepth effort. This study will establish advantages and disadvantages of using a transportation node(s), which will include linear programming models of lunar transportation systems. The study should identify any unique requirements in the Civil Needs Data Base (CNDB) with particular emphasis on a lunar base requirements. A preliminary design of a lunar base will be made. In the design, critical factors will be identified, design requirements will be generated, parametric studies will be conducted, interface requirements will be generated and necessary technological developments will be identified.

Interdisciplinary Technology

W87-70098 **(23) 506-90**
Langley Research Center, Hampton, Va.
INTERDISCIPLINARY TECHNOLOGY
J. C. South 804-865-2664
(505-90-00)

The objective of this plan is to support activities in high-risk/ yield, innovative research at U.S. colleges and universities through the use of research and training grants. It is intended that these university-generated, high-risk research efforts will lead to relevant research and technology for assimilation into future Office of Aeronautics and Space Technology (OAST) research and technology programs. Support will be provided to the U.S. community of engineering and physical sciences, and universities and colleges for research efforts which conceive, explore, and establish the fundamental principles for innovative technologies which are capable of significantly enhancing or enabling future space missions. The program will provide a well balanced investment in appropriate discipline activities, drawing on the best available talent, facilities, academic programs, and creative ideas emanating from academia. Program participants will be selected by an integrated NASA multidisciplinary peer group. The selection will result in 3-year, annually renewable grants. An annual review of program activities will be conducted for all participants.

W87-70099 **(21) 506-90**
Ames Research Center, Moffett Field, Calif.
INTERDISCIPLINARY TECHNOLOGY
J. N. Nielsen 415-694-5500

The object of this RTOP is to support innovative and high-risk basic research in areas related to space. The program pursues basic investigations of new technologies in fundamental science and engineering needed to satisfy NASA's requirements in space including the technical fields of lasers, cryogenics, materials, applied mathematics, superconductivity, chemistry and physics, human factors, and life support systems. The Ames Basic Research Council accepts unsolicited proposals from universities and judges these on the basis of the degree of innovation and the capacity to complete the task.

W87-70100 **(22) 506-90**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY TECHNOLOGY
M. J. Hartmann 216-433-2954

The objective is to conduct innovative, high-risk/yield research at U.S. colleges and universities in areas related to space. The

program pursues basic investigations of and facilitates exchange of information about new technologies in fundamental science and engineering needed to satisfy NASA's requirements in space. The program is carried out primarily through grants to U.S. universities which are selected by an integrated, multidisciplinary peer group. It allows Office of Aeronautics and Space Technology (OAST) to initiate fundamental studies in areas not presently included in a specific discipline program which can ultimately be assimilated into future OAST research and technology programs.

W87-70101 **(10) 506-90**
National Aeronautics and Space Administration, Washington, D.C.
INTERDISCIPLINARY TECHNOLOGY
Edmund L. Sanchez 202-453-2790

The objective of this effort is to provide for various activities in support of the Space Research and Technology program. These activities include the acquisition of office automation equipment, software and support services and the Resident Research Associateship (RRA) program. Purchases of office automation equipment and software are handled in accordance with established agency procedures. The RRA program is contracted.

Space Systems Technology Programs

Chemical Propulsion Systems Technology

W87-70102 **(22) 525-02**
Lewis Research Center, Cleveland, Ohio.
ADVANCED EARTH-TO-ORBIT SYSTEMS TECHNOLOGY
D. A. Petrash 216-433-2439

Evaluation and validation of technological advances in high pressure, oxygen-hydrogen earth-to-orbit rocket engines will be accomplished in a testbed engine environment. The overall goals are to: (1) test and evaluate the output from the advanced high pressure oxygen-hydrogen program to extend component/subsystem life, reduce operational cost and improve performance, (2) enhance the transfer of the emerging technology items to the development program and (3) allow for more intensive and comprehensive testing than can be accomplished in a schedule driven flight engine program. The specific objectives are to (1) develop an environmental map of the engine operating characteristics and define the loads that influence useful life, (2) evaluate the technology features incorporated in new component designs, (3) define and evaluate advanced control systems to relieve or eliminate the adverse transient conditions that limit life, and (4) define and evaluate health monitoring systems which can detect and identify marginal engine components. The components test program will provide basic data to validate new and existing models and subject potential component advances to the engine environment prior to committing the advancement to the engine development program.

W87-70103 **(62) 525-02**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED EARTH-TO-ORBIT SYSTEMS TECHNOLOGY
A. L. Worlund 205-544-0751

The overall objective of this effort is to test, evaluate, and validate the technological advances of the OAST cryogenic and high density propellants Earth-to-orbit propulsion research and technology program. This technology effort will provide both a mechanism to transfer advancements to operational and/or development programs and the engine system data that can guide future technology emphasis. The plan includes: (1) development of an environmental map of the engine operating characteristics and loads that influence life, (2) development of advanced technology features for new or modified components, and (3) definition/evaluation of an advanced systems to monitor and control the engine. The near-term focus of the chemical propulsion system technology is on the validation of emerging analytical models for durability and performance. The intermediate-term focus is on the readiness verification of mature advanced component features/instrumentation through the analysis, design, and fabrication of the parts necessary to incorporate the features into modified SSME components for engine system test. The long-term focus is on the demonstration of health montoring and control schemes applicable to flight operations.

Space Flight Systems Technology

W87-70104 **(23) 542-06**
Langley Research Center, Hampton, Va.
CONTROL OF FLEXIBLE STRUCTURES FLIGHT EXPERIMENT
W. D. Mace 804-865-3745

The objective of the NASA control of flexible structures (COFS) technology program is to generate a technology data base that will provide the designer with options and approaches to achieve spacecraft performance such as maintaining geometry and/or suppressing undesired spacecraft dynamics. The GOFS program will address analysis and design, ground testing, control methods, and in-space testing to achieve a valid flight ready technology. The program will be focused on the development of technology required to understand and accurately predict and control deformations of large flexible spacecraft in a micro-gravity environment. The program will evolve around major ground and generic in-space testing with increasing spacecraft complexity to validate control/structures design methodologies, control approaches, structural analysis methods, and ground and flight test methods. The products of this program will be validated tools and approaches so that a practical implementation of this technology can be made with confidence. The GOFS plan is scheduled to begin in-space testing by 1991 and to have validated flight-ready control/structures technology by 1994.

Automation and Robotics

W87-70105 **(10) 549-01**
National Aeronautics and Space Administration, Washington, D.C.
AUTOMATION AND ROBOTICS TECHNOLOGY
Lee B. Holcomb 202-453-2747

The purpose of this RTOP is to conduct space operations research with particular emphasis on human capabilities assisted by various levels of automation. The research will be conducted by developing and testing a beam assembly teleoperator (BAT) for use in neutral buoyancy tests. Also, tests will be conducted of closed cabin free flyers, head up displays for control of maneuvering units, simulation of telepresence technology, investigation of the human function in supervisory control, and the investigation of expert system for task assignment and housekeeping aboard a space station. This work will be carried out under a grant to MIT.

W87-70106 **(21) 549-01**
Ames Research Center, Moffett Field, Calif.
AUTOMATION AND ROBOTICS TECHNOLOGY
H. Lum 415-694-6544

The objective is to develop technologies in artificial intelligence and information sciences leading to an image-based advanced machine intelligent system for spaceborne applications. Emphasis is in the areas of spaceborne symbolic processing architectures; knowledge understanding; knowledge acquisition and knowledge implementation; a programming environment for software verification, validation, and automated program development; control and execution for intelligent systems; and machine learning. A cooperative Ames-academia-industry team consisting of world-class researchers has been established to conduct the required research with memoranda-of-understanding established with project centers such as NASA/JSC and NASA/GSFC to transfer the technologies

to project applications such as space station and space shuttle. In addition, the Systems Autonomy Demonstration Program has been initiated to transfer the basic research technologies to real-time mission operations environments and provide a focused demonstration. Program objectives are: Decrease of manpower intensive tasks by at least 50%; decrease of documentation for failure diagnostics by at least 80%; and, increase in productivity by at least 20%.

W87-70107 **(23) 549-01**
Langley Research Center, Hampton, Va.
AUTOMATION AND ROBOTICS TECHNOLOGY
J. F. Creedon 804-865-4915

The objective of the activity is to provide automated manipulator, mobility, sensing, and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, maintenance and repair, structural assembly, and space manufacturing. The development and evaluation of optical sensing/processing are additional objectives of this research. The approach is to conceptualize, evaluate, and verify algorithms, sensors, actuators, software, and system architecture required for remote space operations. The research will be conducted through simulation and laboratory hardware experimental tests. The current plan is to investigate cooperative human/machine control of manipulator systems and to augment the human teleoperator control through the application of advanced control technology to automate the system, elevating the operator to higher levels of supervisory control.

W87-70108 **(51) 549-01**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATION AND ROBOTICS TECHNOLOGY
H. Plotkin 301-286-6185

The GSFC program in robotics research and technology is directed at creating the ability for autonomous robots to generate their own plans for disassembly, assembly, and servicing of complex assemblies, using Computer Aided Design (CAD) derived geometric knowledge bases and spatial reasoning. Laboratory robots execute plans and use sensor feedback to accommodate real-world errors and uncertainties. The program also deals with principles of designing satellite and payloads to be compatible with the use of robots for assembly and servicing.

W87-70109 **(55) 549-01**
Jet Propulsion Laboratory, Pasadena, Calif.
AUTOMATION AND ROBOTICS
Wayne R. Schober 818-354-8581

The general objective is to develop the technology base required in teleoperators, teleoperator human factors, artificial intelligence, and robotics. This will include automated manipulation, sensing, control and actuation technology required for future NASA telerobotics applications. Example applications are space assembly, space construction, satellite servicing, and platform maintenance and repair. The areas of technology will span from operator interface to the end effectors (hands) of the robot and will include: (1) sensing and perception, (2) planning and execution, (3) control execution, (4) operator interface, and (5) system architecture and integration. The general approach has two parts: (1) develop core technology which has multiple applications in automation and robotics, and (2) focus the technology on a series of telerobotics demonstrations in 1988, 1990, 1993, 1997 and 2000 to integrate and accelerate transfer of the diverse technologies through ground-based system proof-of-concept. The telerobotics demonstrations will integrate core technologies to provide system level, ground based, proof-of-concept demonstrations of telerobotics capability.

W87-70110 **(62) 549-01**
Marshall Space Flight Center, Huntsville, Ala.
AUTOMATION AND ROBOTICS TECHNOLOGY
E. C. Smith 205-544-3506

The overall objective of this RTOP is to provide development of the highly experimental technology of telerobotics for orbital assembly and servicing of space stations, platforms, and satellites. This automation and robotics technology program is focused on developing methodology for evaluation and selection of telerobot systems and demonstrations using scaled test tasks and quantitative measurements. The effort will develop sensored task simulators with graduated difficulty and quantitative measurements which can be used in a test methodology for evaluation of telerobotic demonstrations and systems.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

Global Scale Atmospheric Processes

W87-70111 **146-66-01**
Jet Propulsion Laboratory, Pasadena, Calif.
METEOROLOGICAL PARAMETERS EXTRACTION
M. T. Chahine 818-354-2433
(146-72-06)

The overall objective of the proposed research is the development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to: (1) conduct theoretical and applied studies for the development of improved numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the NOAA HIRS/MSU sounders; (2) apply the retrieval methods for simultaneous determination of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea surface temperature, and the distribution of cloud heights and amounts; (3) verify the accuracy of the results by participation in national and international workshops dedicated to this objective and by comparison with colocated radiosonde and sea surface data and with cloud nephanalysis obtained independently from other sources; and (4) apply the results to observe and study various air-surface interaction processes on monthly to seasonal time scales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

W87-70112 **146-66-02**
Jet Propulsion Laboratory, Pasadena, Calif.
GLOBAL SEASAT WIND ANALYSIS AND STUDIES
P. M. Woiceshyn 818-354-5416

Our research is directed towards the incorporation of high-resolution scatterometer marine wind and wind stress measurements in global meteorological research, applications and prediction, and towards the development of techniques for dealiasing and assimilating scatterometer wind data into atmospheric and into coupled atmosphere-ocean models. The major objectives are: (1) to generate kinematic and climatological statistics of the SEASAT scatterometer (SASS) dealiased surface wind fields over the ocean; (2) to perform global and regional meteorological research using the dealiased SASS marine wind fields; (3) to begin a study introducing the orthogonal square-root information matrix filter (SRIF) computer implementation of the Kalman-type estimation process for application to data analysis/assimilation; and (4) to create and improve an expanded SASS dealiased data base for analysis and research by using our algorithms. Tasks are: (1) case studies of storms of special interest (explosive development, unusual structure, and forecast improvement); (2) development of statistics of meteorological parameters of importance in the global circulation of the atmosphere, including spectral statistics and empirical orthogonal function analyses of surface fields; (3) application and impact of SASS marine wind data in equatorial ocean-atmosphere interaction dynamics, global-ocean rainfall estimation, frontal instability, coastal mesoscale phenomena, diabatic marine boundary layer studies, and high-resolution

numerical assimilation/forecast schemes; and (4) error analyses of the dealiased SASS1/SOS-algorithm retrievals of wind speed and direction, correction of errors by revised model function (transfer function), and reprocessing of the dealiased SASS data set.

W87-70113 **146-66-05**
Jet Propulsion Laboratory, Pasadena, Calif.
AIRBORNE RAIN MAPPING RADAR SYSTEM
F. Li 818-354-2849

The objectives of this task are to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. We will also use ARMAR to verify the technique, technology and data processing algorithm for future satellite rain mapping missions such as the proposed Tropical Rain Mapping Mission. In FY-86, we have completed a preliminary design of ARMAR. In FY-87, we will continue to refine the system design, perform cost effectiveness tradeoffs on the hardware subsystems and to begin the fabrication of ARMAR. We will concentrate on the hardware development of the transmitter exciter and receiver of the 35 GHz channel, and on the design of the antenna and the antenna scanning system. A conceptual design and a preliminary design review will be conducted. Appropriate long-lead hardware items will be procured so that the system fabrication for the 35 GHz channel can be completed in FY88.

W87-70114 **146-72-01**
Jet Propulsion Laboratory, Pasadena, Calif.
MICROWAVE PRESSURE SOUNDER
D. A. Flower 818-354-4151

This RTOP supports the third phase of the Microwave Pressure Sounder (MPS) research program, the objective of which is to develop an instrument for the remote measurement of atmospheric pressure at the earth's surface. Extensive design studies have shown that differential absorption measurements in the wings of the 60 GHz oxygen absorption band are capable of providing surface pressure observations with the accuracy and coverage suited to applications in global weather research and operational weather forecasting. These theoretical studies have been supported by an experimental program with a simplified instrument on the NASA CV-990 aircraft. Recent results from these experiments have demonstrated the ability to determine surface pressure with an accuracy of 1 millibar. The specific objectives of this phase of the program are: detailed investigation of the limits to the validity of oxygen and water vapor spectroscopic models and the improvements of the models where possible; development and testing of precision calibration techniques and MPS subsystems suitable for use in a satellite instrument; and an investigation of the capabilities of the combined use of active and passive remote sensing instruments for meteorological observations. The approach will be to develop precision calibration techniques and improved MPS subsystems and to test these in the present aircraft instrument. Data acquired with the instrument on NASA's CV-990 aircraft will be used to investigate the limits of the present oxygen and water vapor spectroscopic models. A study will be initiated on the use of passive remote sensors in combination with the MPS instrument to define the advantages of using the sensors in combination for meteorological measurements. Results of these studies will be applied to the design of a satellite MPS.

W87-70115 **146-72-02**
Jet Propulsion Laboratory, Pasadena, Calif.
TROPOSPHERIC TEMPERATURE SOUNDER
H. H. Aumann 818-354-8375

The ultimate objective of this effort is to develop a tropospheric and surface temperature sounder, which complements the Advanced Microwave Sounding Unit (AMSU) on Landsat satellites, in an effort to meet the requirements of the numerical weather prediction models of the 1990s. Over the past eight years we have developed an infrared Advanced Moisture and Temperature Sounder (AMTS) which establishes the highest level of performance achievable with a stand-alone infrared sounder with current technology. However, while AMTS is technically feasible and achieves superior performance compared to currently operational sounders, compared to the current generation sounders it is a large and complex state-of-the-art instrument. During FY-87 we propose to initiate an effort to explore a middleground between AMTS with high performance and high complexity, and the current sounders with less performance and lower hardware complexity. This effort will build on experience gained from the AMTS design, but channel selection will be based on being complementary to the AMSU. We expect this to result in a significant decrease in instrument complexity. Detailed channel selection and performance requirements will be based on inputs from the NASA/NOAA infrared sounder study team.

W87-70116 **146-72-03**
Jet Propulsion Laboratory, Pasadena, Calif.
IR REMOTE SENSING OF SST
D. E. Hagan 818-354-7073
(161-30-03)

The objective of this research is to understand and describe, from infrared measurements in the 8 to 13 micron range, the propagation of radiation in the atmospheric boundary layer, in order to assess the limiting value of water vapor content for which realistic sea surface radiances can be extracted from spaceborne measurements. The approach is to use a new high precision IR radiometer with a measurement strategy that is designed to address the above problem during a series of experimental aircraft flights. Vertical path attenuation measurements will be made from a balloon airship for dry and wet atmospheric conditions to explore the dependence of the continuum extinction and boundary flux exchange on the partial pressure of water vapor, the total pressure and temperature. This research will be co-investigated by Dr. C. B. Farmer, Atmospheric and Oceanographic Science Section, 322.

W87-70117 **146-72-04**
Jet Propulsion Laboratory, Pasadena, Calif.
TROPOSPHERIC WIND MEASUREMENT ASSESSMENT
R. T. Menzies 818-354-3787

The objective of this program is to evaluate certain aspects of the Doppler laser radar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurement of atmospheric wind velocities have been analyzed, e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared rangegated lidar, with the results indicating that the Doppler lidar technique is the superior technique for tropospherical wind field measurements. During FY87, the work will continue on an experimental study of vertical profiles of atmospheric backscatter at various CO2 laser wavelengths in the 9 to 11 micrometers region. This study will be conducted using an existing TEA CO2 lidar facility, employing a single-longitudinal-mode (SLM) injection-controlled TEA laser transmitter and a heterodyne receiver. The use of air parcel trajectory analysis capabilities at UCLA will be co-ordinated in order to study the dependence of aerosol backscatter on the history of the air panel. Continued experimental studies of the correlation time of the aerosol backscatter signal (which is an important parameter for coherent lidar detection analysis) will be conducted.

W87-70118 **146-72-05**
Jet Propulsion Laboratory, Pasadena, Calif.
AMSU RESEARCH STUDIES
R. K. Kakar 818-354-7748

The objective of this investigation is: (1) to optimize the capabilities and specifications of Advanced Microwave Sounding Unit (AMSU), the next generation microwave sounder system for NOAA operational applications; (2) to develop techniques for retrieving meteorological parameters from microwave radiometric measurements; and (3) to define operational and/or experimental microwave radiometric systems beyond AMSU. The proposed research will consist of radiative transfer studies, numerical simulations, planning and evaluation of field experiments, and the analysis of measured data to verify the feasibility of measuring various meteorological parameters with microwave radiometry.

Meteorological parameters to be addressed include temperature and water vapor profiles, precipitation intensity and distribution. The necessary measurement program will be carried out with the airborne Advanced Microwave Moisture Sounder (AMMS) in collaboration with Dr. T. T. Wilheit of NASA/GSFC.

W87-70119 **146-72-06**
Jet Propulsion Laboratory, Pasadena, Calif.
ATMOSPHERIC PARAMETER MAPPING
K. J. Hussey 818-354-4016

The primary objective is to continue development of the image processing capability to produce very high quality color maps and time-lapse imagery of global atmospheric parameters derived from NOAA HIRS2/MSU satellite data. Other objectives include: increasing the cost effectiveness of map production making the process of climatic map generation and data analysis more readily available to atmospheric scientists, and providing continuing support to M. Chahine in the development of new parameter maps derived from the combination and integration of existing data fields. To allow the continuation of high quality and cost effective time series image research and production, a stand alone microcomputer based workstation will be procured and the image processing procedures to efficiently use the workstation will be written. This includes the facility to process the data and then animate the data onto video tape for universal distribution. A time series sequence displaying atmospheric dynamics will be produced to demonstrate this capability. Procedures to facilitate interactive scientific data interpretation and reduction will be improved. To insure procedures are user friendly, atmospheric scientists will be asked to participate in the improvement of the procedures. In addition, existing software will be modified to operate within the workstation environment.

W87-70120 **146-72-09**
Jet Propulsion Laboratory, Pasadena, Calif.
ATMOSPHERIC DYNAMICS AND RADIATION SCIENCE SUPPORT
C. Elachi 818-354-5356

The objective of this task is to support the NASA Atmospheric Dynamic and Radiation Branch in the development and scientific use of remote sensing techniques to study atmospheric dynamic phenomena in the lower atmosphere, such as wind fields, pressure fields, and precipitation. The approach will consist of encouraging distinguished scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists and to explore new ideas and concepts of direct relevance and interest to the atmospheric dynamics and radiation program.

W87-70121 **146-72-10**
Jet Propulsion Laboratory, Pasadena, Calif.
LIDAR TARGET CALIBRATION FACILITY
R. T. Menzies 818-354-3787
(146-72-04; 146-72-11)

The primary objective of the JPL Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO2 lidar targets. The customer will provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO2 laser wavelength, incident and reflected polarizations, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. A secondary objective is to measure the depolarization properties and the proximity to Lambertian (diffuse) behavior of customer-supplied and experimental target surfaces. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a Lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to the primary standard, and the eventual field use of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce speckle effects. Continuity between the three measurements will include: (1) target continuity; (2) illumination continuity (wavelength, polarization, and bandwidth); and (3) geometric continuity (polar angles, solid angles, and target size to beam size relationship).

W87-70122 **146-72-11**
Jet Propulsion Laboratory, Pasadena, Calif.
ATMOSPHERIC BACKSCATTER EXPERIMENT
R. T. Menzies 818-354-3787
(146-72-04; 146-72-10)

The objective of this program is to support studies of the feasibility and scientific value of an Earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol backscatter coefficients at wavelengths in the 9 to 11 micron range over large geographical regions. Emphasis is upon those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of nadir directed, range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation will initially consist primarily of the design and fabrication of an airborne CO2 lidar, which would be mounted on the NASA DC-8 (or equivalent) research aircraft and configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the ground. The lidar would be flown on the NASA DC-8 on at least one latitude survey mission over the Pacific Ocean, and possibly on the flight series dedicated to Southern Hemisphere measurements. The data obtained will be analyzed and considered in the context of related instrument measurements of atmospheric aerosols and other atmospheric parameters.

Upper Atmospheric Research Program

W87-70123 **147-11-05**
Lyndon B. Johnson Space Center, Houston, Tex.
IN-SITU MEASUREMENTS OF STRATOSPHERIC OZONE
D. E. Robbins 713-483-4464

The objective of this research is to contribute to a better understanding of stratospheric ozone photochemistry and to study the impact of man-made compounds upon the ozone. We will develop, improve, and utilize the ultraviolet absorption photometry technique (with the Dasibi technology) for an experimental package small enough to be flown piggyback on balloon platforms carrying experiments to measure other stratospheric species. Results will be compared with measurements of experiments using other techniques and differences will be resolved, especially in the region near 40 km that is critical to the proposed depletion of ozone by fluorocarbons. Efforts will be undertaken to test stratospheric photochemical models, especially by studying reactions involving specie families (such as NOx).

W87-70124 **147-11-07**
Jet Propulsion Laboratory, Pasadena, Calif.
BALLOON-BORNE DIODE LASER ABSORPTION SPECTROMETER
C. R. Webster 818-354-7478

The Balloon-Borne Laser In-Situ Sensor (BLISS) task has as its primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of change in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDLs) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines a 1-km absorption path. The TDL beam in use is stabilized onto the lowered retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity,

throughout a diurnal cycle, and with the additional possibility of altitude profiling.

W87-70125 **147-12-06**
Jet Propulsion Laboratory, Pasadena, Calif.
BALLOON MICROWAVE LIMB SOUNDER (BMLS) STRATOSPHERIC MEASUREMENTS
J. W. Waters 818-354-3025
(673-18-49)

The objective of this program is to improve understanding of Earth's upper atmosphere by balloon-based microwave measurements. Well-founded concerns that man's technological activities may perturb upper atmospheric balances, particularly those maintaining stratospheric ozone, justify this objective. The approach is to first determine which measurements are needed for atmospheric research and perform calculations to define which subset of these can be usefully performed by microwave techniques. A field program is then established for those measurements of sufficient value. The field program may involve instrument development or improvement. One important goal of this program is to determine both the capabilities and limitations of microwave techniques so they can be used efficiently in NASA's overall Upper Atmosphere Research Program. The plan of this research program for the current year is to use the improved sensitivity of the JPL Balloon Microwave Limb Sounder (BMLS) in a NASA-coordinated measurement program to improve understanding of how chlorine from industrial sources might deplete stratospheric ozone. The BMLS operates simultaneously in three spectral bands near 205 GHz to measure thermal emission from ClO, O3, and H2O2.

W87-70126 **147-12-15**
Jet Propulsion Laboratory, Pasadena, Calif.
FAR INFRARED BALLOON RADIOMETER FOR OH
H. M. Pickett 818-354-6861

A stratospheric hydroxyl radical (OH) radiometer for balloon observations in the far infrared region will be developed. This instrument will use three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101 cm(-1) (99 micron wavelength). The resolution will be 0.001 cm(-1) (30 MHz) to match the stratospheric OH spectral line profile. Calculations indicate that the instrument will have sensitivity for retrieving useful OH concentration profiles between 25 km and 46 km with 3 km vertical resolution. The instrument is compact (approximately 0.1 cubic meters), light-weight (approximately 30 kg), requires low power (approximately 25 W) and thus is well-suited to balloon observations.

W87-70127 **147-14-07**
Jet Propulsion Laboratory, Pasadena, Calif.
MICROWAVE TEMPERATURE PROFILER FOR THE ER-2 AIRCRAFT FOR SUPPORT OF THE STRATOSPHERIC/TROPOSPHERIC EXCHANGE PROJECT
B. L. Gary 818-354-3198

The proposed task is to conduct observations with an airborne radiometer that is installed in the NASA ER-2 aircraft. The radiometer measures air temperature versus altitude, which can be used to estimate potential vorticity for the air mass through which the aircraft is flying. Potential vorticity can be used as a tracer for stratospheric air. The identification of stratospheric versus tropospheric air is a key part of the STEP (Stratospheric/Tropospheric Exchange Project), of which this task is one element. An elevation-angle-scanning passive microwave radiometer has been constructed for STEP during previous years of this task. Air temperature profiles have been measured for layers of air that are several thousand feet thick. These profiles have been used to demonstrate that lapse rate can be monitored with time scales of 14 seconds. Wind vector measurements will be combined with lapse rate to derive potential vorticity. Special STEP flights are planned for the Australia/Indonesia region during January/February, 1987. RTOPs submitted by the Ames Research Center STEP project explain how the potential vorticity data will be used to constrain meteorological theories for mechanisms that produce an exchange of air across the tropopause/stratosphere boundary.

W87-70128 **147-16-01**
Jet Propulsion Laboratory, Pasadena, Calif.
MULTI-SENSOR BALLOON MEASUREMENTS
J. H. Riccio 818-354-4415
(147-12-05; 147-12-06; 147-12-08)

A continuing series of stratospheric balloon flights is conducted to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. A modular gondola system is used to carry a multi-instrumented package consisting of several JPL remote sensing instruments, or instruments from other institutions in the U.S. and abroad, configured for a particular scientific purpose for any one flight. Data are obtained on the altitude profiles for a number of chemically coupled species all at the same time and in the same air mass for instrument intercomparison purposes and for the validation of atmospheric chemical models.

W87-70129 **147-18-02**
Jet Propulsion Laboratory, Pasadena, Calif.
GAS CORRELATION WIND SENSOR
D. J. McCleese 818-354-2317

The objective of this task is the development of a measurement technique for remote sensing of stratospheric and mesospheric wind velocities from spacecraft. The measurement technique is based on the determination of wind induced Doppler shifts of thermal emission spectra of selected molecular species such as N2O and CO2. Doppler shifts are measured with a new type of gas correlation spectrometer that utilizes electrooptic phase modulation of emission spectra to bring about spectral correlation of Doppler shifted spectra. Laboratory measurements, together with atmospheric radiation transfer calculations, show that wind induced doppler shifts can be measured in the 20 to 100 km altitude range with an accuracy of better than 5 m/s. The approach is through the continued laboratory development and testing of the electrooptic phase modulation gas correlation spectrometer and the development of mathematical models to assess the performance and science return of a spaceborne gas correlation wind sensors.

W87-70130 **147-21-03**
Jet Propulsion Laboratory, Pasadena, Calif.
CHEMICAL KINETICS OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The objective of this research is to obtain direct measurements of rate constants and temperature dependences for reactions of HO(x), NO(x), ClO(x),BrO(x) and RO(x) in stratospheric chemistry, and to develop techniques for laboratory study of relevant transient species.

W87-70131 **147-22-01**
Jet Propulsion Laboratory, Pasadena, Calif.
PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The objective is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

W87-70132 **147-22-02**
Jet Propulsion Laboratory, Pasadena, Calif.
ATMOSPHERIC PHOTOCHEMISTRY
M. J. Molina 818-354-5752

Laboratory studies will be conducted to elucidate the photochemistry of the atmosphere. Measurements will include reaction rate constants involving radicals and various polar molecules over an extended pressure and temperature range; absorption cross sections as a function of wavelength and temperature; and FTIR spectra of reaction intermediates.

W87-70133 **147-23-08**
Jet Propulsion Laboratory, Pasadena, Calif.
INFRARED LABORATORY SPECTROSCOPY IN SUPPORT OF STRATOSPHERIC MEASUREMENTS
R. A. Toth 818-354-6860

The program involves the acquisition of laboratory spectra and the analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the JPL infrared interferometers. These instruments have requirements relative to spectral regions of operation, spectral resolution, and molecules for which they are best suited. Emphasis is placed on accuracy of line frequency, line width, and line strength measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements.

W87-70134 **147-23-09**
Jet Propulsion Laboratory, Pasadena, Calif.
LASER LABORATORY SPECTROSCOPY
C. R. Webster 818-354-7478

The laser laboratory spectroscopy program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from laser stratospheric measurements, specifically by the BLISS infrared laser instrument. Line positions, absorption strengths, and air broadening coefficients are the spectral parameters measured. New spectroscopic techniques for laser wavelength calibration and spectral lineshape analysis are also investigated.

W87-70135 **147-23-10**
Jet Propulsion Laboratory, Pasadena, Calif.
MILLIMETER/SUBMILLIMETER LABORATORY SPECTROSCOPY
E. A. Cohen 818-354-4701

A program of laboratory studies related to stratospheric research will be conducted in millimeter and submillimeter spectroscopy. The program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the JPL millimeter radiometer instruments. Emphasis is placed on accuracy of line frequency, line width, and transition movement measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements.

W87-70136 **147-51-01**
Jet Propulsion Laboratory, Pasadena, Calif.
DATA SURVEY AND EVALUATION
W. B. DeMore 818-354-2436

An up-to-date tabulation and critical evaluation of kinetic and photochemical data relevant to the stratosphere will be maintained for use by atmospheric modelers, to aid in the establishment of research priorities, and to identify gaps or inconsistencies in the database.

W87-70137 **147-51-12**
Jet Propulsion Laboratory, Pasadena, Calif.
INTERDISCIPLINARY SCIENCE SUPPORT
M. T. Chahine 818-354-2433

The objective of this RTOP is to support the NASA Earth Sciences and Applications Division in the development and application of remote sensing techniques to study land surface processes and their interactions with the atmosphere. The science support to the NASA Earth Systems Science Program will be provided through the assistance of Professor R. Goody and Professor S. I. Rasool, Prof. Ronald Prinn, Dr. Paul Blanchard, Prof. M. McElroy and Dr. Jim Baker. Additional science support could be added subject to JPL and NASA-OSSA Code EE mutual agreement.

W87-70138 **147-52-01**
Jet Propulsion Laboratory, Pasadena, Calif.
DETAILEE/UPPER ATMOSPHERE RESEARCH PROGRAM
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the Earth Science and Applications Division, by the assignment of a JPL detailee to NASA Headquarters. The primary duties of the detailee will be to coordinate present and future activities of the NASA Upper Atmosphere Research Program, and to assist in the development of an interdisciplinary Earth Science Research Program.

Planetary Geology R&A

W87-70139 **151-01-20**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY GEOLOGY
W. C. Phinney 713-483-3816

The broad objective of the study of planetary surface processes is to develop a coherent body of data on planetary surface processes which can be used to design planetary missions and to interpret data as well as place boundary conditions on planetary evolution. The study of appropriate analogues not only places boundary conditions on the evolution of other planets such as Mars but also permits, on Earth, the evaluation of the characteristics of planetary surface instrumentation. Future exploration of Mars and other planets includes surface analysis and sample return missions. The development of these missions requires suitable instrumentation for analyses on the surface of mars and analogues of Martian surface material. Specific objectives are: (1) to determine through detailed grain-by-grain studies of several terrestrial soils the processes and history that can be deduced through such data, (2) to characterize the gases released by thermal decomposition of Martian surface analog materials and evaluate the feasibility of accomplishing such analyses in situ, (3) to map the volcanic stratigraphy on the surface of Io, and (4) to determine the thermochemical properties and kinetics of potential regolith material on Mars and Venus, and (5) to compare the landforms of Venus and Earth.

W87-70140 **151-01-60**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY: AEOLIAN PROCESSES ON PLANETS
B. F. Smith 415-694-5515

The objective of this activity is to determine the parameters governing aeolian (wind) processes in various planetary environments by means of wind tunnel simulations, laboratory experiments, Earth analog studies, and analyses of spacecraft data. The approach will be to conduct experiments using wind tunnel and other laboratory apparatus to study at various atmospheric pressures and compositions: (1) conditions for the initiation and sustainment of particle movement; (2) erosion and deposition around various landforms; (3) rates of erosion of various natural materials; and (4) scanning electron microscopy of surface textures produced by wind abrasion under planetary conditions. Field experiments will be conducted to determine threshold conditions under natural conditions and to determine aeolian patterns around full-scale landforms, and a field-portable anemometer array will be used for studying the dynamics of particle motion and bedform development. Long-tern field experiments will continue on the aeolian erosion under natural conditions to provide a check for the laboratory experiments. Spacecraft data from the Viking and Venera missions will be analyzed to interpret aeolian processes on Mars and Venus.

W87-70141 **151-02-50**
Goddard Space Flight Center, Greenbelt, Md.
MARS GEOLOGY: CRUSTAL DICHOTOMY AND CRUSTAL EVOLUTION
Herbert Frey 301-344-5450

The objectives of this research are to: develop an understanding of the origin and development of the fundamental crustal dichotomy on Mars and of the boundary scarp which separates the cratered highlands from the northern lowland plains; determine the extent to which relic pieces of old cratered terrain are present within younger geologic units; determine crater retention ages for morphological subunits within the transition zone; and develop a model for the resurfacing history of this boundary. The approach will be to conduct photogeologic mapping of features characteristic of the highland boundary scarp and ancient cratered terrain (detached plateaus, knobby terrain, partial and whole craters); produce maps of fractional areal distributions, correlate these with topography and with surface material properties; develop regional characterization of the boundary scarp and transition zone. Use cumulative frequency curves for impact craters to assess the number and age of major resurfacing events which have modified the highland boundary and other major blocks of old cratered terrain; and compare boundary scrap analogs on other planets.

W87-70142 **151-02-60**
Ames Research Center, Moffett Field, Calif.
NASA-AMES RESEARCH CENTER VERTICAL GUN FACILITY
T. E. Polek 415-694-5269

The Ames Research Center Vertical Gun Range is a ballistic facility used to simulate and study the physics and mechanics of planetary impact cratering phenomena. Ballistic technologies, utilizing light gas and gun powder, enable acceleration of projectiles up to 2 centimeters diameter at relative velocities of approximately 8 km/sec. By varying the gun's angle of elevation with respect to the target vacuum tank, impact angles from 0 degrees to 90 degrees with respect to the gravitational vector are possible. In conjunction with the Lunar and Planetary Institute, Ames Research Center (ARC) operates the Ames Vertical Gun Facility as a national facility. ARC's responsibility is to manage the Vertical Gun Facility operations, including manpower, expendables, targets, etc.; maintain equipment and provide for facility modification and upgrading, as needed. ARC operates the facility in such a manner as to provide maximum support to the scientific community in the studying and understanding of impact processes in planetary formation and modification.

W87-70143 **151-02-61**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF PLANETARY BODIES
J. B. Pollack 415-694-5530

The purpose of this research is to obtain a better understanding of selected problems pertaining to planetary surface phenomena, the composition, structure and evolution of planetary bodies and their satellites, and the origin of the solar system by means of theoretical investigations employing the results of spacecraft and ground-based experiments. Theoretical knowledge, physical insight, and mathematical modeling techniques are used, together with astronomical and geological data, to construct self-consistent mathematical descriptions of planetary processes and structures. Analysis and interpretation of the results of these model calculations are applied to such topics as wind-blown surface features and climatic changes on Mars, and aeolian phenomena on Venus and Titan.

W87-70144 **151-02-63**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY: AEOLIAN PROCESSES ON PLANETS
B. F. Smith 415-694-5515

The objective of this activity is to develop and operate wind tunnels used to simulate aeolian (wind) processes in various planetary environments. The Venus and Mars wind tunnels will be configured to analyze the development of bedforms, the interaction of windblown particles with atmospheres, and the effects of atmospheric instability on surface processes. Also, a new tunnel is to be constructed and calibrated for airborne microgravity feasibility tests.

W87-70145 **151-02-64**
Ames Research Center, Moffett Field, Calif.
MARTIAN GEOLOGIC FEATURES AND PLANETARY PROCESSES
S. W. Squyres 415-694-5491

The purpose of this research is to obtain a better understanding of selected problems pertaining to the origin, evolution, and present state of planets and satellites. Problems of particular interest deal with geological processes on Mars and icy satellites, the physics of cometary nuclei, accretional heating of planets and satellites, and the evolution of jovian planets. A variety of techniques is used to investigate the problems under consideration. These include geologic mapping and interpretation, quantitative analysis of spacecraft data, and development of numerical models of surface processes. Examples of problems to be considered include study of the geology of Ganymede, modeling of ice-induced quasi-viscous relaxation of topography on Mars, modeling of geologic processes on Ganymede and Europa, calculations of heat transport processes in icy regoliths, numerical modeling of accretional heating of icy satellites and terrestrial planets, investigation of the gamma-ray signal originating from Martian volatiles, investigation of the photometric properties of the satellites of Saturn and Uranus, and study of the survival of planetesimals as they enter the atmospheres of growing jovian planets.

W87-70146 **151-02-65**
Ames Research Center, Moffett Field, Calif.
FORMATION, EVOLUTION, AND STABILITY OF PROTOSTELLAR DISKS
P. M. Cassen 415-694-5597

The objectives of this research are to obtain an understanding of the solar nebula and proto-stellar disks in general by analysis of theoretical models based on hydrodynamic and thermodynamic principles, and to relate these models to processes of planetary formation. Research is currently being concentrated in the following areas: (1) development of a theory of the generation of bipolar stellar winds as a natural stage in the formation of stars and disks; (2) theoretical analysis of mechanisms of angular momentum transport within protostellar disks; and (3) the analysis of conditions in the solar nebula as inferred from meteoritic inclusions and grains.

W87-70147 **151-02-67**
Ames Research Center, Moffett Field, Calif.
RING DYNAMICS AND MORPHOLOGY
J. N. Cuzzi 415-694-6343

The objective of this research is to understand the processes which determine the structure of planetary ring systems and to explore and test hypotheses of their origin and evolution. It is likely that the dynamical processes operating today in ring systems are analogous to those which accompanied the formation of the planets from their own particle disk. Along with theoretical studies, complementary analyses and interpretations of ground-based and spacecraft observations are pursued. Both ring structure and particle properties are of interest.

Planetary Materials

W87-70148 **152-11-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: MINERALOGY AND PETROLOGY
I. D. Browne 713-483-6241

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objective is to learn the pressure, temperature and chemical composition of distinct mineralogic phases at the time of their formation. Textures, structures and chemical composition of minerals found in samples

of the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids) and the Earth will be measured using optical and electron microscope and electron microprobe techniques. Comparison of these results with those from laboratory calibration experiments and theoretical models will lead to pressure, temperature and history information for parts of Solar System objects.

W87-70149 **152-12-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY
I. D. Browne 713-483-6241

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objective is to execute laboratory experiments and develop theoretical models which aid our understanding of the crystallization behavior of rock-forming minerals. Mineral systems similar to those found in samples from the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids) and the Earth will be studied experimentally by observing the products of crystallization from experimental charges of known composition cooled under known pressure and temperature conditions. Comparison of these results with the mineralogy of naturally-occurring samples will lead to pressures temperature, and history information for parts of these Solar System objects.

W87-70150 **152-12-40**
Goddard Space Flight Center, Greenbelt, Md.
A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRESOLAR GRAINS
B. Donn 301-344-6859
(188-41-51; 154-75-80)

The objectives of this program are: (1) Perform experiments to determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species. (2) Determine the structure and composition of solids condensed from cosmically abundant refractor mixtures. (3) Monitor changes which occur in these materials as the result of thermal annealing, hydration, exposure to cosmic rays. The results will be a major contribution to characterizing the nature of grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored via a quadrupole mass spectrometer. This data will yield the concentration and stability of pre-condensation clusters as a function of composition. Objectives 2 and 3 require a separate flow system, designed to produce grains rather than clusters, and able to produce large amounts of multicomponent grains. The structure and composition of these initial grains will be determined via X-ray and electron diffraction and energy dispersive studies, the infrared and UV/visible spectra will be obtained and the particle morphology will be studied via Scanning Electron Microscopy (SEM) and Scanning Transmission Electron Microscopy (STEM). Samples of these materials will be annealed at controlled temperatures for various times exposed to either liquid or gaseous water or in a 1 MeV proton beam and the changes thus induced studied by the above techniques.

W87-70151 **152-13-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: CHEMISTRY
I. D. Browne 713-483-6241

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objective is measure the concentration of selected chemical elements (major, minor, and trace) in rock samples of interest. Data obtained supplement, and are often combined with, petrologic studies to yield bounds on thermodynamic parameters at the time of rock origin. Rock samples from the Moon, meteorites (asteroids, comets), cosmic dust (comets, asteroids, Mars) and the Earth will be analyzed using a variety of sophisticated techniques, including neutron activation analysis (NAA), X-ray fluorescence, atomic absorption spectrophotometry, gamma-ray spectrometry, and proton-induced X-ray emission. Relative abundances of trace elements in different samples places bounds on the characteristics of the sources from which the rock-forming materials are derived.

W87-70152 **152-13-60**
Ames Research Center, Moffett Field, Calif.
PLANETARY MATERIALS-CARBONACEOUS METEORITES
S. Chang 415-694-5733

The objective of this research is to understand the processes involved in the origin and early evolution of solid bodies in the solar system through the study of meteorites. The approach taken to meet the objectives focuses on the chemical and mineralogical-petrographic analyses of meteorites. The abundance, isotopic composition and distribution of selected elements are measured; and the occurrence and distribution of various mineral phases are determined. Systematic searches for elemental, isotopic and mineralogic-petrologic correlations between meteorites and within a meteorite will be made so as to elucidate physical-chemical relationships in the meteorite population. From these relationships will be deduced the nature of the processes that were involved in the origins, accretion and distribution of these objects and their components in the early solar system. In turn these processes are modeled by laboratory or computer experiments from which the chemical and mineralogical outcomes can be determined. Findings from meteorite analyses and model studies are then compared for self-consistency.

W87-70153 **152-14-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: GEOCHRONOLOGY
I. D. Brown 713-483-6241

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objectives is to determine the absolute time when a particular event, such as the eruption of a volcano of the formation of a large impact crater, occurred. The concentrations of radioactive decay products and the corresponding parent isotopes will be measured in carefully selected rock samples using mass spectrometric techniques. With knowledge of the decay constant (half life) for the radioactive element, and assuming a closed chemical system, the time since system closure may de deduced. Systems currently in use are: K-Ar, Rb-Sr, Sm-Nd, Lu, Hf and U-Th-Pb. Study of extinct radioactive nuclides, such as Pu, leads to information on the interval of time between the formation of the nuclide and its incorporation into a solid.

W87-70154 **152-15-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: ISOTOPE STUDIES
I. D. Browne 713-483-6241

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objective is to determine the isotope composition of selected elements in planetary materials. Isotopically distinct material, which cannot be understood as the product of known fractionation processes, may indicate the presence of pre-solar material. Light elements are studied to learn more about fractionation processes. A secondary objective is to develop and ion microprobe which will provide easier analysis and increased spatial resolution and sensitivity for isotopic composition measurements. Samples of moon rocks and meteorites will be analyzed using mass spectrometric techniques to learn isotopic compositions, mainly of noble gass, hydrogen, carbon, oxygen and nitrogen. Theoretical calculations will be made to relate the expected products of nucleosynthesis to observations of anomalous material in meteorites. A commercially purchased ion microprobe is being upgraded in the laboratory of G. J. Wasserburg, CIT.

W87-70155 **152-17-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES
I. D. Browne 713-483-3274

The general objective is to obtain information about the nature, origin and evolution of the Solar System. The specific objective is to learn about the interaction between the space environment, which consists of meteorites, galactic cosmic rays, and solar particle and electromagnetic radiations. Samples of the lunar regolith offer the opportunity of find variations in the intensity of the environmental factors over geologic time. A variety of approaches will be used. The radioactivity of cosmic-ray produced nuclides will be analyzed as a function of sample depth. Surfaces will be studied using electron microscopes. Etchable heavy element ionization damage tracks will be revealed and studied. Solar wind noble gases will be analyzed mass spectrometrically. Multidisciplinary studies will be done using selected samples.

W87-70156 **152-19-40**
Lyndon B. Johnson Space Center, Houston, Tex.
EARLY CRUSTAL GENESIS
W. C. Phinney 713-483-3816

Meaningful models are to be developed for the evolution of the solar system, then physical and chemical constraints must be developed for the processes involved in the evolution of the solid objects in the solar system. The specific objectives are: to identify the key physical and chemical processes and the initial conditions for crustal evolution, to understand the evolution of planetary crusts in relationship to the overall history of individual planetary bodies, and to understand the reasons for the differences in evolution among the various planetary crusts. The strategy is to adopt an interdisciplinary and cross-planetary approach to the questions of crustal genesis. The program is a multidisciplinary effort carried out by individual scientists and teams from universities, industries, and government agencies. Major effects will be devoted to: studying samples that are related to the early formed crusts, searching for early terrestrial crustal units, studying materials from potential terrestrial analogs of early planetary crusts, and modeling crustal evolution.

W87-70157 **152-20-40**
Lyndon B. Johnson Space Center, Houston, Tex.
PLANETARY MATERIALS: COLLECTION, PRESERVATION, AND DISTRIBUTION
D. P. Blanchard 713-483-3274

The objective provides for maintenance of the Lunar Sample Collection under secure, controlled environment conditions; for the description of samples as new materials are prepared for analysis; for the maintenance records of the status and distribution of lunar samples; for lunar samples to be given to approved investigators and for display purposes; and for technical monitoring of NASA-funded grants/contracts to Planetary Materials Investigators. Similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; dissemination of information on meteorite collection; and staff members participation in field are also provided. The collection of cosmic dust samples using high altitude aircraft; the characterization of dust particles; distribution to scientific investigators; and dissemination of information are provided. Development of curatorial techniques for, and educational use of, materials from the various collections are covered. The operation, is undertaken by support contractor personnel, is directed by Civil Servant scientists and administrators. The program provides samples and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and six to ten cosmic dust investigators.

W87-70158 **152-30-40**
Lyndon B. Johnson Space Center, Houston, Tex.
GENERAL OPERATIONS AND LABORATORY FACILITIES - PLANETARY MATERIALS
M. B. Duke 713-483-4464

General operations support a variety of institutional and scientific support tasks at Johnson Space Center (JSC) that are considered essential for the conduct of research and for implementation of the Planetary Materials and Geochemistry Program (PMGP). Center support services such as printing, computer, photographic, and graphics are provided to the Lunar and Planetary Institute through a procedural agreement. Inhouse support provides for co-sponsorship of conferences, laboratory costs required by visiting scientists using existing facilities, and for cost required to operate common laboratory facilities and to provide for support services from other Center elements. This plan also provides inhouse laboratory maintenance and Center Operations support for the visiting scientist program of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.) A significant addition to this RTOP is a plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefitting NASA and other agency programs. The PMGP is asked to support about 20% of the modernization.

Planetary Atmospheres R&A

W87-70159 **154-10-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-694-5530

Theoretical modeling and spacecraft data interpretation are used to determine the properties and physical processes characteristic of planetary atmospheres. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Pioneer Venus and Voyager or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

W87-70160 **154-20-80**
Ames Research Center, Moffett Field, Calif.
DYNAMICS OF PLANETARY ATMOSPHERES
R. E. Young 415-694-5521

The dynamics of the atmospheres of Venus and Mars are being studied using multi-dimensional circulation models. The coupled momentum and energy equations are solved numerically using combinations of finite difference and spectral methods. The principal goals are to compare model results with spacecraft data and attempt to understand the dynamical effects of varying planetary rotation rate, solar energy deposition, infrared opacity, atmospheric mass and composition. In addition to the modeling studies, participation in the French/USSR VEGA Mission balloon experimental studies of the Venus atmospheric structure and dynamics is continuing by Ames scientists working as part of the U.S. Science Team for this Mission. This work includes review of experimental approach, calibration review and analysis, and analysis of the mission data.

W87-70161 **154-30-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY CLOUDS PARTICULATES AND ICES
O. B. Toon 415-694-5971

The project goals are: (1) to determine the physical and chemical processes responsible for the cloud structures observed on Mars, Titan and Venus; (2) to better define the cloud structure

on Titan by reanalyzing Voyager data; (3) to provide comparisons between terrestrial and planetary clouds; (4) and to use computer models to provide a self-consistent framework for determining cloud properties from first principles of physics and chemistry. A generalized planetary cloud computer code was developed which now allows approach to a large number of problems from a consistent framework. The model was used to simulate the haze on Titan, and is being readied to investigate the polar hoods and water ice fogs of Mars.

W87-70162 **154-40-80**
Goddard Inst. for Space Studies, New York.
RADIATIVE TRANSFER IN PLANETARY ATMOSPHERES
L. Travis 212-678-5599

This RTOP supports all planetary research at GISS other than specific tasks which are part of Goddard Institute for Space Studies (GISS) spacecraft experiments: Orbiter Cloud Photopolarimeter (OCPP) on Pioneer Venus and Photopolarimeter/radiometer (PPR) on Galileo. The general objectives are to: (1) develop and apply techniques for extracting information on planetary atmospheres from remote sensing of scattered and emitted radiation, and (2) investigate the interactions and feedbacks between radiative, cloud and dynamical processes in planetary atmospheres. Applications to Venus and Jupiter in progress are expected to yield general information on cloud structure and aerosol microphysics as well as the role of clouds on radiation budget and convective processes. Information on these interactions has relevance for other atmospheres including climate processes for the Earth. Principal elements in the approach are: (1) analysis of available spectral and polarimetric data for Venus and Jupiter to obtain information on atmospheric structure, and (2) radiative-convective and general circulation modeling to investigate interactions between clouds, radiation, and dynamics.

W87-70163 **154-40-80**
Jet Propulsion Laboratory, Pasadena, Calif.
REMOTE SENSING OF ATMOSPHERIC STRUCTURES
G. S. Orton 818-354-2460

The objective of this research is the development of accurate numerical approaches for the interpretation of infrared remote sensing data obtained under realistic conditions in the presence of anticipated measurement noise as well as in the presence of clouds and aerosols. Five important problems will be addressed: (1) determination of atmospheric temperature profiles in the presence of clouds and aerosols when cloud cover is uniform or when temperature and cloud variations are highly correlated, (2) determination of both macro- and microphysical cloud properties, (3) determination of temperature in the presence of strong positive temperature gradients, (4) determination of gaseous abundance profiles in the presence of clouds, (5) assembly of requisite molecular spectroscopic data for the application of these techniques in the outer solar system. The approach will use standard relaxation techniques, coupled with accurate and efficient radiative transfer algorithms, together with a simultaneous theoretical approach to these problems. Testing of these techniques will be done using numerical simulations of data, comparing the conditions of the generating model with those retrieved by the technique. The model test environments of significance in the near term will be the outer planets and Mars, in support of Voyager and Galileo data analysis and future mission experiment planning.

W87-70164 **154-50-80**
Goddard Space Flight Center, Greenbelt, Md.
ATOMIC AND MOLECULAR PROPERTIES OF PLANETARY ATMOSPHERIC CONSTITUENTS
Donald E. Jennings 301-344-7701

The principal goal of this laboratory spectroscopy program is to develop an organized body of knowledge of the molecular properties of planetary atmospheric constituents. In the case of lower-resolution planetary observations, such as Voyager Infrared Interferometer Spectrometer (IRIS) (4), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features apparent in medium or high resolution Fourier transform (FTS) spectra are composed of more than one molecular transition, and the parameters (1) frequency, (2) strength, (3) lower-state energy, and (4) foreign-broadening must be known for each as input in modeling the atmosphere. For FTS and infrared heterodyne observations the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL) and FTS laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared. In this program TDL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species. Task include: improve Jupiter, Saturn, and Titan abundances using available lab data; measure temperature-dependent H2 broadening of C2H6, measure temperature-dependent strengths in C2H6, C3H8, and C2H4; continue analysis of methylacetylene near 15 microns; and complete analysis of 14-micron bands of C2H2.

W87-70165 **154-60-80**
Marshall Space Flight Center, Huntsville, Ala.
GAS UV SPECTROMETER
J. H. Waite, Jr. 501-544-7635

This proposal is to support the reflight of an existing extreme ultraviolet/far ultraviolet spectrometer in a Get Away Special (GAS) canister on the shuttle to observe the Jupiter, Saturn, and Uranus planetary systems over the wavelength range 600 to 1900 A. The major task proposed here is the modification of the optical system from an f/2 to an f/10 focal length optical system which will enable increased spatial resolution of the instrument. This increased resolution is necessary for resolving spatial features within the Jovian atmosphere and the extended Io torus.

W87-70166 **154-60-80**
Jet Propulsion Laboratory, Pasadena, Calif.
AERONOMY THEORY AND ANALYSIS/COMET MODELS
W. T. Huntress, Jr. 818-354-8275
(154-75-80)

Theoretical chemical models will be constructed for the chemical structure of cometary comae. The objective is to derive constraints on the initial composition by comparison with observation, and thus make deductions concerning the origin of comets. The primary data for comparison will be that from the Giotto mission and spectroscopic images taken with CCD instruments from ground-based observations.

W87-70167 **154-60-80**
Ames Research Center, Moffett Field, Calif.
MULTI-DIMENSIONAL MODEL STUDIES OF THE MARS IONOSPHERE
R. C. Whitten 415-694-5498

The objective of this research is to arrive at realistic predictions of ion densities, flow velocities and temperatures over the day and night sides of the Mars ionosphere in order to establish ranges and properties for use in a future Mars Aeronomy Mission. Simple calculations have shown that the Coriolis force can be neglected to first order; hence two-dimensional (2-D) models (mainly spectral) of ion density, flow velocity, and temperatures are justified and are being constructed. Although some preliminary results have been obtained, it is expected that most of the useful 2-D calculations will be performed in FY-87. Extension of the models to include the Coriolis force will be started in FY-87 and the computation of ion density, velocity and temperature carried out in FY-88.

W87-70168 **154-90-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS
W. J. Borucki 415-694-6492

The general objectives of this research are to determine the

role of atmospheric electrical processes in the evolution of planetary atmospheres and to delineate the electrical and meteorological processes that give rise to the extreme electric fields required for lightning. The general approach is to use comparative planetology; i.e., to compare the spacecraft observations with terrestrial observations and theory in order to understand the processes occurring on other planets and to check the applicability of the theories that have been developed to explain terrestrial lightning and atmospheric electricity. Efforts will be directed toward determining the location of the lightning activity on Venus and Jupiter and toward determining the roles of condensible vapors and air-mass convergence. The electrical charging of aerosols and droplets will also be considered.

W87-70169 **154-90-80**
Marshall Space Flight Center, Huntsville, Ala.
PLANETARY MAGNETOSPHERIC COUPLING
J. H. Waite, Jr. 205-544-7635

The objective of this RTOP is an adequate understanding of thermospheric and ionospheric processes in the Jovian, Saturnian, and Uranian planetary systems. This research involves modeling of aeronomical processes in the upper atmospheres of Jupiter, Saturn, and Uranus and the comparison of these results with the existing data from the Voyager program and ultraviolet spectrometer observations scheduled to be made using the International Ultraviolet Explorer (IUE) telescope in 1986. The proposed modeling tasks include: (1) the modeling of energetic O(+q) and S(+q) ion auroral precipitation processes including energy dissipation, ionization, and emission production rates, and the first-order aeronomical consequences of ion auroral precipitation; (2) development of a follow-up time-dependent model of the Jovian upper atmosphere studying the chemical effects of oxygen precipitation once it is slowed and thermalized in the upper atmosphere; (3) modification of the Jovian time-dependent upper atmosphere model to study the effect of H2O precipitation from the rings of Saturn on the structure and composition of the ionosphere and upper atmosphere of Saturn; (4) interpretation of the Voyager/Uranus UVS and Radio Science results; and (5) study of the electroglow problem in the upper atmospheres of Jupiter, Saturn, and Uranus.

Mars Data Analysis

W87-70170 **155-04-80**
Ames Research Center, Moffett Field, Calif.
PHYSICAL AND DYNAMICAL MODELS OF THE CLIMATE ON MARS
R. Haberle 415-694-6343

The climate of Mars is characterized by the seasonal cycles of dust, water and carbon dioxide. While the Mariner 9 and Viking spacecraft missions have provided a good first order definition of the amplitude and phase of these cycles, the processes controlling them remain uncertain. The objective of this work is to further our understanding of the processes controlling these cycles. The approach is to numerically simulate various aspects of these cycles using one and two-dimensional climate models. The one-dimensional model is a time-marching radiative-convective model that includes the solar and infrared radiative effects of dust as well as carbon dioxide. It is used to isolate the effects of dust on temperature structure and the condensation of carbon dioxide in the atmosphere and ground. The two-dimensional model is a zonally symmetric primitive-equation model with a tracer transport capability. It is used to study the role of atmospheric transport on the water cycle, and the radiative-dynamical feedback effects of dust on the general circulation.

W87-70171 **155-20-70**
Jet Propulsion Laboratory, Pasadena, Calif.
PLANETARY DATA SYSTEM AND COORDINATION
J. T. Renfrow 818-354-6347
(656-80-01)

The objectives are to develop and implement an operational Planetary Data System (PDS), to restore planetary science data sets for inclusion in the PDS, to develop the required ancillary navigation data support capabilities needed for effective utilization of the planetary science data sets, and to provide coordination among all producers of planetary science data at JPL. JPL will develop the operational PDS in conjunction with the integrated science testbed systems that have been started and continue to be funded by the Information System Office of Code E. The technologies identified and evaluated under this allied task are being incorporated into the operational PDS. All the system engineering and system implementation activities of both the science testbeds and the operational PDS will be conducted under this RTOP in order to have effectively coordinated development. The mission interface between the PDS and the planetary missions will be defined and implemented. The process of selecting discipline and data nodes for the operational PDS will be developed and the members of the planetary science community will be given the opportunity to propose to become discipline and data nodes. Standards and data storage strategies will be developed for use in performing data restoration activities. The functional capabilities necessary to provide ancillary (i.e., navigation) information and data to support the planetary data will be developed so as to interface directly with the operational PDS. A data system coordinator will continue to serve as an interface between the planetary science community and the planetary data system developments at JPL.

W87-70172 **155-20-80**
Ames Research Center, Moffett Field, Calif.
MARS EXOBIOLOGY RESEARCH CONSORTIUM
G. C. Carle 415-694-5765
(199-52-52)

The objective is to develop a better understanding of the Martian surface geochemistry and its overall relationship to volatile distributions, sources, sinks, and cycles from the exobiologist's perspective. An inventory of candidate mineral phases as models or analogs of Martian surface composition will be developed. A data base of laboratory reflectance spectra with which to assess Mars Observer Mission (MOM) surface reflectance spectra will be established and the effect of Martian environmental parameters on spectral features of mineral models will be determined.

Halleys Comet Watch/Experiments

W87-70173 **156-02-02**
Jet Propulsion Laboratory, Pasadena, Calif.
INTERNATIONAL HALLEY WATCH
R. L. Newburn, Jr. 818-354-2319

The International Halley Watch (IHW) has been designed to maximize the scientific value of ground-based observations of Halley's Comet. Important in their own right, such observations have also enhanced the value of space observations, setting the brief duration flyby data in the context of the overall apparition, placing the extremely high resolution encounter data into the normal scale of observations, and filling in missing data. The IHW has standardized observing techniques wherever useful and possible, coordinated the observing, and is now collecting data for publication in a comprehensive Halley Archive. The IHW has been designed to avoid the problems of 1910 where the two major monographs on Halley were not published until 21 and 24 years later and where much data remains unpublished to this day. The Giacobini-Zinner Watch (GZW) provided support to the International Cometary Explorer (ICE) mission and complements the IHW by using the same ground-based techniques at the same time to study another very different comet or comparison. Individual nets of observers worldwide have been organized for each observing technique by eight Discipline Specialist teams. Overall IHM coordination internally and with flight projects is the responsibility of a Lead Center Organization (LCO) established in Pasadena, Ca. USA and

Bamberg, FRG, as is responsibility for IHW publications. Advice and oversight protection are supplied by a 29 member steering group. Each flight project interfaces formally with the IHW through a project appointed project representative. Amateur contributions are being coordinated by the LCO, working through recorders (amateur comet specialists) and existing amateur organizations. The Giacobini-Zinner Watch has utilized the full, existing IHW apparatus, manpower, communications, etc. Additional funds have been used only to process actual G-Z data.

W87-70174 **156-02-02**
Goddard Space Flight Center, Greenbelt, Md.
THE LARGE-SCALE PHENOMENA PROGRAM OF THE INTERNATIONAL HALLEY WATCH (IHW)
John C. Brandt 301-344-5821

The major objectives of this program are: (1) to construct a worldwide network of observatories with wide-field imaging capability for participation in the Large-Scale Phenomena portion of the International Halley Watch (IHW); (2) to scientifically analyze the imagery obtained from the net using sophisticated state-of-the-art computer image processing techniques; (3) to standardize and archive the image data for eventual submission to the permanent Halley Archive at JPL; and (4) to provide support to the deep space comet Halley missions flown by international space agencies. The International Halley Watch (IHW) is an organization whose steering group is composed of members from many countries and whose purpose and function (the advocacy of worldwide observations of Halley and the collection and analysis of any data such obtained) was officially endorsed by the International Astronomical Union (IAU). The present Investigators (J. C. Brandt and M. B. Niedner) were selected as Discipline Specialists for the Large-Scale Phenomena program of the IHW. This program will be administered via the construction of a worldwide network for the observation of large-scale phenomena such as rapidly-variable plasma-tail features and similarly wide-field dust-tail structures. The modus operandi requires the forwarding by participating observatories of their best photographic plates (or film copies) to the Science Team for analysis. Individual observatories retain full proprietary rights to the analysis of their own data whereas the Discipline Specialists and their Team reserve the right to analyze the worldwide data as a whole. Following analysis, plates will be returned to the observatories which forwarded them and film copies will be permanently stored in the IHW Halley Archive.

W87-70175 **156-03-03**
Jet Propulsion Laboratory, Pasadena, Calif.
GIOTTO - ION MASS SPECTROMETER, CO-INVESTIGATOR SUPPORT
M. Neugebauer 818-354-2005

During the encounter of the GIOTTO spacecraft with Halley's comet, the High Energy Range Spectrometer (HERS) (NASA sponsored) sensor of the Ion Mass Spectrometer (IMS), (Balsiger *et al., 1986ab) obtained unique information concerning the chemical* composition of cometary gases and the plasma interactions of comets with the solar wind. HERS found anomalously large amounts of C(+) ions, and the data suggested that N(+) is low in abundance. The dynamical interaction of the cometary ions with the solar wind and cometary neutrals resulted in such features as a heavy ion mantle, a drop-out region closer to the comet, a bow shock with complex internal structure, a contact surface separating solar wind and cometary plasmas, and nonequilibrium plasma distribution functions. Experimental results will be used to further understanding of the origin of comets, the chemical processes that determine the composition of the cometary plasma, and the plasma dynamical, MHD, and neutral interaction processes that determine the velocities and distributions of the ions. Quantitative analysis of the mass spectra, use of the measured flow field as input to chemical models, and comparison of observations with chemical models are planned. Bow shock data will be correlated with results of other experiments, theoretical modelling will determine expected pick-up distributions, and comparison of these models to observations will characterize pitch-angle scattering and thermalization. Interactions by collision and charge-exchange with the neutrals will be investigated. The temporal/spatial structure of the ions should provide evidence concerning the Kelvin-Helmholtz instability, MDH wave instabilities, flux ropes, rays, etc., if present. Software for data reduction, analysis, and modelling will be developed for these purposes, and limited calibration runs on the flight spare unit are planned.

W87-70176 **156-03-04**
Jet Propulsion Laboratory, Pasadena, Calif.
GIOTTO PIA CO-INVESTIGATOR SUPPORT
Z. Sekanina 818-354-7589

The flight data from the Giotto Particulate Impact Analyzer (PIA) experiment provide an extensive data base for studying the chemistry, mineralogy, and other properties of microscopic dust particles emitted from Comet Halley. Work of the four U.S. co-investigators under this RTOP task (Brownlee, Clark, Sekanina, Utterback) will address the following objectives: (1) study of effects of particle-collisional ionization and dissociation (including multiple ionization), surface desorption-type reactions, and recombination processes on the mass spectra, identification of atomic/molecular equivalents to the individual peaks in the spectra, and determination of the ionization efficiencies of the various species to derive their relative abundances; (2) elemental analysis and interpretation of the results in terms of the chemical, isotopic, and mineralogical composition of the dust particles, determination of particle masses, and estimation of particle bulk densities; (3) classification of particles by their composition and relative abundances into major groups and subgroups, and comparison with potentially relevant compositional analogs of extraterrestrial origin such as interplanetary particles, interstellar grains, and meteorites; (4) study of particle structure, optical and dynamical properties, and possible fragmentation, relationships between structure and composition, comparison between the PIA results and those from the Dust Impact Detection System (DIDSY) experiment and from ground-based observations in terms of the particle-mass distribution and dust-flux profile along the spacecraft's trajectory, and possible compositional variations over the nucleus surface; and (5) overall characterization of the properties of Halley's dust-particle population and conclusions on the origin and evolution of Halley and comets in general, based on the experiment's results.

W87-70177 **156-03-05**
Goddard Space Flight Center, Greenbelt, Md.
GIOTTO, MAGNETIC FIELD EXPERIMENTS
Mario H. Acuna 301-344-7258

We have participated in the magnetometer experiment for the GIOTTO mission to Comet Halley. The experiment has provided rapid (up to 30 vectors/sec), precise (0.1%), accurate and very sensitive + or - 0.004 nT) vector measurements over a wide dynamic range (7 ranges from + or - 16 nT to + or - 65538 nT, with the uppermost ranges for easy check-out during S/C integration) of the magnetic fields observed during the GIOTTO encounter of Comet Halley in March 1986. Near closest approach we are most interested in the signature in the magnetic field of dynamical processes originating near the cometary nucleus. Another major objective is the study of the interaction between Comet Halley and the solar wind at 0.897 AU. This includes the identification of boundary surfaces such as the cometary bow shock and the transition region between a cometary magnetosheath and the cometary atmosphere closer to the comet. In addition, we shall investigate the role of the magnetic fields in the coma and magnetosheath, dynamical phenomena in the plasma interaction caused by temporal variations of the cometary gas and plasma source during the fly-by and wave phenomena generated by instabilities in the various magnetoplasma regions and regimes.

W87-70178 **156-03-07**
Jet Propulsion Laboratory, Pasadena, Calif.
GIOTTO DIDSY CO-INVESTIGATOR SUPPORT
Z. Sekanina 818-354-7589

The flight data from the Giotto Dust Impact Detection System (DIDSY) experiment provide an extensive data base for studying the distribution of dust in the atmosphere of Comet Halley. Work

of the two U.S. co-investigators under this RTOP task (Hanner, Sekanina) will deal with the following problems: (1) spatial density of dust as a function of the position on the spacecraft trajectory in the full range of particle masses and the total production of dust by the comet at the time of encounter; (2) particle-mass distribution function, the probable upper and lower limits on particle masses, and the particle bulk density as a function of mass (allowing conversion from the mass distribution to the size distribution function); (3) synergistic studies aimed at a global understanding of the flight data and their comparison with information from other experiments and with ground-based optical observations, including the determination of the source function of dust on the nucleus surface; (4) relationship between the mass, spatial and temporal variations derived from the DIDSY data and from infrared remote sensing data; and (5) overall interpretation of the dust-release processes and their effects on the evolution of Comet Halley.

Planetary Instrument Definition

W87-70179 **157-01-70**
Jet Propulsion Laboratory, Pasadena, Calif.
ADVANCED CCD CAMERA DEVELOPMENT
S. A. Collins 818-354-7393

The objective of this task is to complete the development of a large-format charge coupled devices CCD (1024 squared) and to procure and archive a quantity of these devices for use in imaging systems which will be flown on future planetary spacecraft. This task is a continuation and completion of work which is currently underway. A suitable 1024-squared CCD has been developed and demonstrated. During FY-87 and the balance of FY-86, additional units will be fabricated and archived for use in future planetary spacecraft imaging instruments. This program is expected to yield several dozen flight-quality CCDs and to provide for future availability of such devices at reasonable, reliable costs.

W87-70180 **157-03-08**
Jet Propulsion Laboratory, Pasadena, Calif.
MARINER MARK II IMAGING
T. Fraschetti 818-354-2931

The objective of this program is to continue the development of the Imaging Science Subsystem (ISS) facility instrument for use on Mariner Mark II missions, the first mission being Cometary Rendezvous Asteroid Flyby (CRAF). Major objectives include the following: (1) complete procurement of the narrow angle optics engineering model initiated in FY-86; (2) complete thermal and structural analysis on the narrow angle opto-mechanical design; (3) perform environmental evaluation of the wide angle optics breadboard model which was designed and fabricated in FY-86; (4) generate specification documents and initiate opto-mechanical design of the wide angle optics engineering model; and (5) provide support to the ISS team.

W87-70181 **157-03-40**
Lyndon B. Johnson Space Center, Houston, Tex.
DEFINITION AND DEVELOPMENT OF A THERMAL IONIZATION MASS SPECTROMETRY (TIMS) INSTRUMENT FOR REMOTE PLANETARY ANALYSES
L. E. Nyquist 713-483-5579

Continued development of a spacecraft instrument to perform remote analyses of planetary silicates by thermal ionization mass spectrometry (TIMS), a versatile research tool of the geological sciences, is proposed. The instrument concept is most fully described in a proposal submitted in response to the A. O. for the Cometary Rendezvous Asteroid Flyby (CRAF) Mission, but the instrument could be adapted to missions to chemically differentiated objects (planets, Earth's Moon, some other satellites, differentiated asteroids) as well as undifferentiated objects (comets, primitive asteroids). The mass spectrometer would be of the design used successfully on Atmosphere Explorers-C, -D, and -E by Prof. A. O. Nier of the University of Minnesota. Prior work has proven concepts required by the Sample Processing System (SPS), which provides for chemical processing of samples prior to transfer to a mass spectrometer for thermal ion analysis. Models of several critical components have been developed and some commercially available components have been tested while verifying key concepts of the SPS. Designs for a Sample Collection System (SCS) for collecting cometary dust and for interfacing the SPS and SCS to a mass spectrometer are in a preliminary stage. A method for direct collection of cometary dust followed by analysis without chemical processing, a recently developed feature of the instrument concept, is included in the concept for the mass spectrometer interface. Packaging of the instrument has been considered as part of the CRAF proposal and volume, mass, power, and data rates are within reasonable limits. Additional development plus refurbishment of extensively used existing hardware is required before an end-to-end breadboard model of the system could be assembled.

W87-70182 **157-03-50**
Goddard Space Flight Center, Greenbelt, Md.
X-GAMMA NEUTRON GAMMA/INSTRUMENT DEFINITION
J. I. Trombka 301-344-5941

The objective of this investigation is to develop remote-sensing and in-situ measurement systems for geochemical and geophysical exploration of the planets, asteroids and comets. These studies will be consistent with planetary program recommended by the Solar System Exploration Committee (SSEC). The remote-sensing X-ray spectrometer study will consider proportional counters, solid-state detectors, and imaging systems. Elemental composition for elements with atomic numbers greater than $Z=6$ (carbon) using solar X-ray fluorescent spectral measurements are being considered. Both theoretical and experimental studies will be used in the investigative program. Both gamma-ray and X-ray detector systems are significantly affected by the space radiation environment. Both induced backgrounds and radiation damage in gamma-ray detectors (i.e., NaI(Tl), CsI(Na), Ge(Li) and Ge(High Purity)) have been studied and methods for predicting the magnitude of these effects of the space radiation environment on X-ray detectors. Balloon flights of remote sensing gamma-ray and X-ray spectrometer systems will be conducted in order to ascertain their sensitivities and the magnitude of the space environment induced activity. Our group has established the feasibility of obtaining sub-surface elemental composition of a comet nucleus using a passive gamma-ray spectrometer system on a penetrometer probe. Designs of detector systems for such missions will be carried out using both theoretical and experimental methods.

W87-70183 **157-04-80**
Ames Research Center, Moffett Field, Calif.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM - TITAN ATMOSPHERIC ANALYSIS
G. C. Carle 415-694-5765
(199-52-52)

The objective is to develop flight instrument capability and hardware prototypes for the comprehensive analysis of the gases and aerosols in the atmosphere of Titan from an entry probe. This work will develop critical elements of a flight gas chromatograph (GC) system to collect, thermally process, and analyze aerosols and to collect and analyze gases (with special emphasis on high altitude samples) along the entry path of the Titan-Cassini probe. The analytical concepts and prototype instruments will be validated using a Titan wind tunnel which will drive model Titan organic aerosols and atmospheric gases over prototype sample collectors simulating the transit of an entry probe through the atmosphere.

W87-70184 **157-04-80**
Ames Research Center, Moffett Field, Calif.
STUDY AND DEVELOPMENT OF A COMET NUCLEUS PENETRATOR - OVERGUIDELINE
Byron L. Swenson 415-694-5705

The objective of this program is to define and develop the Comet Nucleus Penetrator (CNP) as a viable experiment for the

proposed Comet Rendezvous and Flyby (CRAF) mission). The CNP is a device to emplace a gamma-ray spectrometer, an alpha particle instrument, and temperature instrumentation beneath the surface of the comet nucleus to determine the elemental and isotopic composition and the thermal state and properties of the unaltered nucleus material. Accelerometers will also be used to determine the bearing strength and layering of the material near the surface. Work under this continuing development effort will include in-house and contracted activities to understand various design issues and the continuation of critical impact testing to develop the instruments and the penetrator configuration.

W87-70185 **157-04-80**
Jet Propulsion Laboratory, Pasadena, Calif.
DIODE LASER IR ABSORPTION SPECTROMETER
C. R. Webster 818-354-7478

The objective of this task is the definition and development of a tunable diode laser infrared absorption spectrometer (TDLS) for in-situ atmospheric composition measurements under NASA's program of planetary exploration. Particular emphasis will be given to the development of a probe instrument for the in-situ sensing of Titan's atmosphere on the Saturn Orbiter/Titan Probe (SOTP) NASA-ESA joint mission. The TDLS spectrometer uses several narrow bandwidth (< or = 0.0002/cm) tunable diode lasers operating near 80 degrees Kelvin at selected, mid-infrared wavelengths (3 to 30 microns). For the absorption measurements, these sources are directed over a 1-m open pathlength defined by a small retroreflector located 0.5 m away. Because of the high sensitivity of diode laser derivative detection methods, volume mixing ratios of < or = 10(-8) should be measurable for most species of interest: vertical profiles of the concentrations of molecules such as CH4, CO, CO2, HCN, C2H2, C2N2, C3H4, C3H8, C3HN, C4H2 can therefore be determined, with a vertical resolution of a few km from probe entry to the surface. In addition, determination of atmospheric pressure, temperature, and scattering (nephelometry) is possible using the same instrument.

W87-70186 **157-05-50**
Goddard Space Flight Center, Greenbelt, Md.
PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/ PLANETARY ASTRONOMY
M. J. Mumma 301-286-6994

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task-O2 addresses the development of compact, power efficient infrared heterodyne spectrometer components suitable for eventual space flight use. Particular emphasis is placed on developing RF-excited waveguide CO2 lasers, and miniaturized integrated spectral line receivers.

Solar Terrestrial and Astrophysics ATD

W87-70187 **159-38-01**
Jet Propulsion Laboratory, Pasadena, Calif.
SOLAR DYNAMICS OBSERVATORY/SOLAR OSCILLATIONS IMAGER
E. J. Smith 818-354-2248

This RTOP provides for the systems analysis and engineering tests required in the predesign phase of a Solar Oscillations Imaging Experiment (SOI). Evaluation of the Magnetooptical Filter (MOF) as a suitable flight analyzer will require the development and test of an engineering analyzer and a math model of its performance. Also included in this RTOP are tasks necessary to support a facility class instrument, provide science support to the Helioseismology Steering Committee (HSC) and Solar and Heliospheric Observatory (SOHO) mission and documentation in support of a joint NASA/ESA announcement of opportunity scheduled to be released in the first quarter of 1987.

W87-70188 **159-38-03**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED MISSION STUDY SOLAR X-RAY PINHOLE OCCULTER FACILITY (POF)
Joseph R. Dabbs 205-544-0623

Hard X-ray imaging of the Sun in the range 10 - 100 kev is very important in understanding energetic processes such as solar flares of the active Sun. There have been very important results in recent years in imaging hard X-rays. The Pinhole Occulter Facility (POF) is a novel instrumentation concept which uses a 32 meter deployable boom to position a mask which provides occultation for coronal telescopes. It also provides coded array and Fourier-Transform apertures for hard X-ray imaging. The purpose of the facility is to image the solar disk in the X-ray spectrum at higher energies than previously possible and to study the solar corona with greater sensitivity to lower limb heights and with greater angular resolution. It also has the capability of imaging celestial sources in hard X-rays. The POF is intended for one Spacelab flight and to be transitioned to the space station as an important building block in the Advanced Solar Observatory (ASO).

W87-70189 **159-41-01**
Jet Propulsion Laboratory, Pasadena, Calif.
A STUDY OF THE LARGE DEPLOYABLE REFLECTOR (LDR) FOR ASTRONOMY APPLICATIONS
P. N. Swanson 818-354-3273
(196-41-73)

The overall objectives of this RTOP are to provide science definition and leadership for Large Deployable Reflector (LDR), continue pre-phase A system definition through modeling and analysis, and help define, guide and contribute to specific technology development tasks. The JPL LDR scientist is a member of the Science Coordinating Group (SCG) and JPL will fund the activities of this group. The SCG will oversee the LDR Science activities. Non U.S. participation in LDR will be investigated. The LDR technical manager will provide technical coordination between the various technical development efforts both internal and external to JPL. This will also include the interfaces with the Ames Research Center, LaRC, MSFC and OAST which are vital to the continuing success of LDR. This will be accomplished, in part, by holding periodic LDR program reviews, including NASA, universities and industry participation. Specific system design issues that were identified at the Asilomar Workshop will be studied. These include, but are not limited to, background limiting radiation analysis, two stage optics design and analysis, thermal control of the LDR optics and the effect of orbits and observational time lines. Inputs to, and interfaces with the OAST funded JPL and Langley Systems Model will be made in the areas of optics, controls, structures, thermal behavior and system operation. In the technical development areas of lightweight reflector panels, pointing, controls, structures and future brassboards, we will provide concepts, designs, analysis and modeling for both JPL and other NASA center activities.

W87-70190 **159-41-01**
Ames Research Center, Moffett Field, Calif.
STUDY OF LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY
D. J. Hollenbach 415-694-4164
(506-62-21)

The Large Deployable Reflector (LDR) will be a 20m diameter reflecting submillimeter/far-infrared telescope, constructed or deployed in space (possibly as the space station), and placed in a free-flying Earth orbit to perform as an observatory for at least 10 years. It is currently in the early planning stage, and it is hoped to be operational roughly in the year 2000. Work under this RTOP is a continuation of activities to refine the scientific rationale and the related set of science requirements and to provide scientific input in defining and developing technical concepts and requirements. Often this work arises from problems emerging in the discussions of the LDR Science Coordination Group, of LDR workshops, with industrial contractors, or with the LDR lead center, JPL. These problems include, for example, studies of LDR

as a light bucket and the use of LDR toward specific scientific goals such as planet detection. Currently, work focuses on thermal background subtraction by LDR: the technological requirements such as nodding and chopping rate and temperature uniformity imposed by the need to achieve the desired sensitivity.

W87-70191 **159-41-06**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF SPACE INFRARED TELESCOPE FACILITY (SIRTF)
J. P. Murphy 415-694-6643

The objectives of this RTOP are to define and develop the Space Infrared Telescope Facility (SIRTF), to define and develop scientific instruments for the SIRTF focal plane, and to develop operational procedures for SIRTF as a free flyer observatory. SIRTF is an observatory that will accept multiple focal plane instruments for use by infrared astronomers. The conceptual studies have identified the key technologies for SIRTF and for the science instruments, and technology development is being conducted. The approach for this RTOP is to: (1) continue development of the technology needed for the design and development of SIRTF; and (2) to coordinate the results of the previous studies and the technology development and to increase the depth of the design definition and systems analysis by performing Phase B studies of the telescope facility and the selected instruments.

W87-70192 **159-46-01**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
D. C. Cramblit 205-544-0569

The Advanced X-ray Astrophysics Facility (AXAF) is a free-flying observatory featuring a high performance X-ray telescope for use over a 15-year lifetime through servicing from space station or STS revisits. AXAF is now completing the definition phase, aimed at long lead item development start efforts in FY-88 and a launch in the 1995 time period. Due in part to advances in metrology and fabrication technology in X-ray optics, AXAF is expected to be 50 to 100 times as sensitive its predecessor, HEAO-2. An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. This RTOP activity will continue to place emphasis on the early development and demonstration of all science instrument and optics technologies critical to achieving AXAF science objectives and assuring a sound basis for program new start readiness in FY-89 or FY-90.

Oceanic Processes

W87-70193 **161-10-08**
Jet Propulsion Laboratory, Pasadena, Calif.
ADVANCED SCATTEROMETRY
F. Li 818-354-2849
(161-80-39)

The objective of this task is to develop advanced technique and technology that will improve the performance of future spaceborne scatterometer and to develop a new, airborne research scatterometer facility that can be used for geophysical research and as a test bed for new technology development. The specific FY-87 objectives are: examine the feasibility of pulse compression technique in a scanning pencil-beam scatterometer, develop a conceptual design for an on-board wind vector processor for spaceborne scatterometers and continue the development of the new airborne scatterometer, NUSCAT, leading to full system integration and test in FY-88. We will examine the scanning geometry involved in a pencil-beam spaceborne scatterometer that can optimize the number of azimuth observation angles. The use of pulse compression techniques to improve radar measurement accuracy will be evaluated. Equations relating signal-to-noise ratio to Kp will be derived for this type of scatterometer. We will also summarize our functional requirements for an on-board processor that can process the raw scatterometer data into unique wind vectors. An architectural design for the on-board processor will be developed. The key deliverable for this activity is a proposal for the development of a breadboard model in FY-88. For the NUSCAT development, we will procure the hardware components for the transmit/receive and the digital subsystems. These two subsystems will be fully fabricated and integrated. We will begin the software development on the digital subsystem so that the total radar system will be integrated and tested in the laboratory in FY-88.

W87-70194 **161-20-07**
Jet Propulsion Laboratory, Pasadena, Calif.
CURRENTS/TIDES FROM ALTIMETRY
M. E. Parke 818-354-2739

The proposed work is intended to study a number of tidal problems that will have an impact on the analysis and use of Topography Experiment (TOPEX) data. The current work on the Patagonian shelf with Seasat data will be extended to three of the other five top dissipative shelf regions. The new orbits that are currently being released for Seasat are being used for a study of the deep water M2 tide. Late in the proposal, this study of the deep water tide will be continued with Geosat data. The North Atlantic will be developed as a test region for experimenting with improved modelling techniques.

W87-70195 **161-30-02**
Jet Propulsion Laboratory, Pasadena, Calif.
OCEAN PRODUCTIVITY
M. R. Abbott 818-354-4658

Temporal and spatial variability of phytoplankton biomass and productivity is in large part a result of fluctuations in physical processes. Long time series of satellite imagery covering a large area will be necessary if we are to understand the interactions of these biological and physical processes. To accomplish these objectives, we are engaged in four activities. First, we are developing complete time series of sea surface temperature (as derived from AVHRR data) and near-surface pigment (as derived from the Coastal Zone Color Scanner (CZCS) imagery) from the California Current domain (20 deg N to 60 deg N) that eventually will span the lifetime of the CZCS. The requirements for these time series were established by the West Coast Satellite Time Series Advisory Group. The data will be freely available through the NASA Ocean Data System. Second, we are analyzing these data, focusing on the climatology of the large filaments that apparently move large amounts of coastal water far offshore and on the comparison of satellite data with ship surveys from CalCOFI. This aspect is jointly funded with ONR. Third, I am analyzing portions of these time series from the Coastal Ocean Dynamics Experiment area and from the shelf area off Vancouver Island (in collaboration with K.L. Denman). This effort is concentrating on estimating temporal and spatial decorrelation scale. Fourth, graduate student at SIO (C. Paden) is analyzing ship and satellite imagery to study the effects of topography and tidal forcing on a front in the Gulf of California. Data have been distributed to investigators in Canada, at Scripps, OSU, APL, U.C. Santa Cruz, U.C. Santa Barbara, and Univ. of Washington.

W87-70196 **161-30-03**
Jet Propulsion Laboratory, Pasadena, Calif.
IR REMOTE SENSING OF SST
D. E. Hagan 818-354-7073
(146-72-03)

The objective of this research is to understand and describe, from infrared measurements in the 8 to 13 micron range, the propagation of radiation in the atmospheric boundary layer, in order to assess the limiting value of water vapor content for which realistic sea surface radiances can be extracted from spaceborne measurements. The approach is to use a new high precision IR radiometer with a measurement strategy that is designed to address the above problem during a series of experimental aircraft flights. Vertical path attenuation measurements will be made from a balloon airship for dry and wet atmospheric conditions to explore the dependence of the continuum extinction and boundary flux

exchange on the partial pressure of water vapor, the total pressure and temperature. This research will be coinvestigated by Dr. C. B. Farmer, Atmospheric and Oceanographic Science Section, 322.

W87-70197 **161-30-05**
Jet Propulsion Laboratory, Pasadena, Calif.
FLUORESCENCE OF MARINE PLANKTON
D. J. Collins 818-354-3473

The research outlined in this proposal includes spectral studies of the fluorescence, absorption and scattering of marine phytoplankton which are required to interpret remotely sensed data obtained from the phytoplankton community in the ocean. These studies include investigations of color group and photoadaptation effects and the development of algorithms for the prediction of primary production. Data has been collected in the laboratory using laser-induced fluorescence to produce the detailed spectra required. These data have been supported by a complete set of biological measurements on the cultures used, including the chlorophyll concentration, the absorption and fluorescence-excitation spectra. Statistical methods are being applied to the spectra, and to the derivative spectra, to determine the relationships between these spectra and the pigment distributions that are characteristics of the taxonomic groups to be studied. The results of these investigations will be applied to the analysis of spectra obtained from oceanic environments characteristic of both open ocean environments through the use of the ODEX data set, and to coastal environments through the use of the OPUS data set, and others.

W87-70198 **161-40-02**
Jet Propulsion Laboratory, Pasadena, Calif.
IMAGING RADAR STUDIES OF SEA ICE
F. D. Carsey 818-354-8163

Our plan is to learn more about ice kinetics and conditions and ice backscatter behavior. We also plan to continue the development of automatic processing algorithms for ice kinetics and type. Data from the Shuttle Imaging Radar flight series and from aircraft will be used for certain types of information, although these flights may be designed for use in another program such as the Alaska SAR Facility. The use of synthetic aperture radar (SAR) to study waves at the ice margin will be pursued if the current work seems to indicate value. The overall objectives of the program are to increase our knowledge of the geophysics of ice-covered seas and to advance the technology of SAR in the observations of sea ice processes. Our approach will include tasks to: learn more about the sub-mesoscale motion of ice and about the geophysics of ice motion, continue to develop computer methods for the extraction of ice geophysical information from SAR images, quantitatively evaluate the behavior of the air-sea-ice system at the ice margin as regards such processes as grease ice formation, swell propagation, floe size and form, and eddy presence, and continue to enlarge the data base on the microwave properties of sea ice by examination of the Seasat SAR and Scatterometer data and by taking part in focused field programs such as the Freezeup Chukchi Sea program. Aircraft data from the JPL SAR aboard the NASA DC-8 are planned in 1988 for both freezeup and Antarctica.

W87-70199 **161-40-03**
Jet Propulsion Laboratory, Pasadena, Calif.
DETAILEE/NJOKU
E. G. Njoku 818-354-5356

The objective of this RTOP is to provide support to the Oceanic Processes Branch, Earth Science and Applications Division, by the assignment of a JPL Detailee to NASA Headquarters. The primary duties of the Detailee will be to coordinate present and future activities of the Ocean Data Systems program, and to assist in the development of future directions for this program.

W87-70200 **161-40-10**
Jet Propulsion Laboratory, Pasadena, Calif.
NASA OCEAN DATA SYSTEM (NODS)
J. C. Klose 818-354-5036
(656-13-40)

The objective of the NASA Ocean Data System (NODS) is to archive and distribute data sets from spaceborne ocean viewing sensors and, to a limited extent, data sets from in-situ measurement systems. NODS will provide a catalog of data sets relevant to ocean science that can be interrogated interactively. Interactive access will be provided to a bibliography system which provides abstracts of documents relevant to data sets referenced in the catalog or held by the archive. NODS will archive data at various processing levels, ranging from level 0, 1, and 2 swath-oriented data to level 3 and 4 gridded data. NODS will produce and archive browse products which are designed to provide rapid response to users wishing to browse through data interactively. Users will be able to select data by time, region, project, sensor, data level, and measurement. Selected data can be displayed at the user's terminal, electronically transmitted to the user or written to magnetic or optical media for shipment to the requester. The NASA Ocean Data System is evolving from the Pilot Ocean Data System (PODS). Science requirements, flight project requirements, and lessons learned during the PODS pilot phase are being incorporated into a new design, which when implemented, will result in an operational system capable of dealing with the data management and distribution requirements of oceanic flight projects of the 1990's. NODS is being developed by extending the existing pilot system to meet NODS requirements. NODS will be implemented as a network of distributed archives. The JPL node will act as the prototype for the other nodes in the NODS network. Newly created nodes will be provided with the JPL developed software, thus ensuring cost efficiency and as much uniformity as possible within the network.

W87-70201 **161-40-30**
Jet Propulsion Laboratory, Pasadena, Calif.
EXAMINATION OF CHUKCHI AIR-SEA-ICE PROCESSES
J. P. Crawford 213-354-6471

The objectives of the proposed research are to: (1) increase the understanding of the geophysical processes of the Chukchi Sea, (2) develop relationships between measured radiances from the SSMI sensor and ice phenomena of the Arctic Ocean and its adjacent seas, and (3) improve ice classification results by combining active and passive microwave data sets. Oceanographic investigations have answered some important questions about Chukchi air-sea-ice processes, but many issues remain. These issues concern the effects of heat transported by bathymetrically channelled flow through the Chukchi, the processes influencing the ice edge, and the role of the shelf break during ice retreat. The proposed effort also deals with understanding the relationships between radiances from the SSMI sensor and sea ice. This is necessary for data validation and fine tuning geophysical algorithms. Justification for examining combined active/passive microwave data sets of ice rests with the assumption that present algorithms have reached their effectiveness limit while still having unsuitably large errors. It also serves as a prerequisite to interpreting coincident ERS-1 C-band SAR and SSMI observations which will be available in the 1990s. Approaches to the research problems involve analyses of historical satellite and airborne microwave observations in conjunction with oceanographic and atmospheric data. They also involve participation in field programs, and implementing methods to evaluate geophysical algorithms and combine satellite data sets. In addition to answering specific questions about Chukchi air-sea-ice processes, participation in field programs will include introducing airborne SAR downlink technology in support of real-time oceanographic research.

W87-70202 **161-50-02**
Jet Propulsion Laboratory, Pasadena, Calif.
OCEANIC REMOTE SENSING LIBRARY
J. E. Hilland 818-354-4787

The objectives are to collect current publications and provide

access to relevant documents through a physical collection and electronic search system and to enhance the information collection by adding pertinent literature requested by library patrons. To provide access to oceanic remote sensing documents the ORSL librarian acquires, organizes and distributes major scientific journals. In addition, DMSP, TOPEX, NSCAT AND NODS reports have been a focus of document acquisition. The ORSL uses the Library of Congress classification system. Material distribution requests are received by mail, telephone, and the NODS on-line bibliography. The NODS online bibliography provides abstract search, extract, review, and order capabilities for JPL researchers and others working at large distances from JPL. Reference citations can be reviewed on a computer terminal and ordered from the ORSL collection. To provide an annotated bibliography the ORSL librarian must: (1) acquire pertinent documents; (2) organize the documents in a manner consistent with standard library practices; (3) maintain an up-to-date collection; (4) distribute documents on demand; and (5) develop ORSL services more fully.

W87-70203 **161-50-03**
Jet Propulsion Laboratory, Pasadena, Calif.
OCEAN PROCESSES BRANCH SCIENTIFIC PROGRAM SUPPORT
C. Elachi 818-354-5673

The objective of this task is to support the NASA Oceanic Processes Branch in the development and use of remote sensing techniques to study physical and biological oceanic processes and their interactions with the atmosphere.

W87-70204 **161-50-07**
Jet Propulsion Laboratory, Pasadena, Calif.
ANALYSIS OF OCEANIC PRODUCTIVITY
C. O. Davis 818-354-4159

This is a new research effort to be initiated upon Dr. Davis' return to JPL from NASA Headquarters. The research will focus on the study of the primary production of the California coastal waters, with particular emphasis on the persistent upwelling features near headlands. This effort will include the use of both CZCS and AVHRR satellite data produced by the West Coast Satellite Color Temperature Time Series under the direction of Mark Abbott. These data will be examined in conjunction with in situ data obtained from the OPUS project to study the role of the physical environment on the distribution of phytoplankton biomass and primary production.

W87-70205 **161-80-15**
Jet Propulsion Laboratory, Pasadena, Calif.
REMOTE SENSING OF AIR-SEA FLUXES
W. T. Liu 213-354-2394

The long-term objective is to study the interactive processes of ocean-atmosphere energy exchanges using spaceborne sensors. The short-term objectives are to develop and implement methods of determining latent heat flux from the ocean using satellite data, and to apply the flux to study the variability of sea surface temperature. Initial feasibility studies have been performed based on SEASAT/SMMR data. A global relation between precipitable water measured by spaceborne sensors and surface-level humidity required to determine latent heat flux has been established. Nimbus/SMMR data from 1980 to 1983 are being evaluated and reprocessed to study the annual and interannual variation of latent heat flux and sea surface temperature in the tropical Pacific. An experiment project, the TOGA Heat Exchange Project (THEP), has been established to coordinate satellite data verification and combination for surface heat flux determination in conjunction with the Tropic Heat and Tropical Ocean and Global Ocean (TOGA) experiments. New methods to improve the accuracy are under consideration and the possibility of a future spaceborne sensor dedicated to study ocean heat balance will be explored.

W87-70206 **161-80-37**
Jet Propulsion Laboratory, Pasadena, Calif.
THEORETICAL/NUMERICAL STUDY OF THE DYNAMICS OF OCEAN WAVES
M. H. Freilich 818-354-7801
(161-80-39)

The objectives of this work are to: (1) investigate the interactions of centimetric water waves with both the wind and long wave fields, and to determine the implications of these interactions for the interpretation of scatterometer measurements; (2) develop realistic models describing wave-induced water motions in the coastal environment; and (3) participate in data analysis activities associated with the FASINEX data set. Current theories of short-wave dynamics in the presence of winds and longer waves are being refined. Based on laboratory measurements by others showing that wind stress is concentrated on relatively small areas of the sea surface, detailed models of the fluid flows in both the air and water boundary layers over steep waves are derived. Characteristics of the flows leading to centimetric wave generation/dissipation are examined. Comparisons between SASS and surface measurements are used to illustrate effects of waves, temperatures, and stability on existing model functions. Nonlinear one-dimensional wave shoaling models are extended both inside and outside the surf-zone. Inside the break zone, the 1-D model is used to predict the generation of low-frequency surf beat. Outside the break zone, a 2-D model will include refractive effects and allow prediction of longshore currents. Comparisons between conventional stress measurements are used to determine relative accuracies of the measurement techniques. Stress, and and auxiliary data will be combined to examine deficiencies in present model functions and to begin development of a sigma(0)-stress model function.

W87-70207 **161-80-38**
Jet Propulsion Laboratory, Pasadena, Calif.
OCEAN CIRCULATION AND SATELLITE ALTIMETRY
L.-L. Fu 213-354-8167

The long-term objective of the research activities covered under this RTOP is to investigate the utility of satellite altimetry for observing the general circulation and variability of the oceans. The approach taken is to analyze GEOS-3, SEASAT, and GEOSAT data with emphasis placed on error reduction techniques. Following are some near-term objectives: (1) investigation of techniques for reducing orbit errors in altimetric measurement (particular attention will be paid to the method of Fourier analysis versus the method of optimal estimation); (2) investigation of the scientific utility of the crossover difference data from the Navy GEOSAT Mission (collaboration with W. White and C. K. Tai of SIO); (3) investigation of the validity of several environmental and geophysical corrections applied to SEASAT data (sea state bias, water vapor delay, and inverse barometer effects) with a purpose to aid the algorithm development for future missions.

W87-70208 **161-80-40**
Jet Propulsion Laboratory, Pasadena, Calif.
STUDIES OF SEA SURFACE TOPOGRAPHY AND TEMPERATURE
V. Zlotnicki 818-354-5519

The first objective of this work is a quantitative assessment of the spatial structure of the errors in the three available altimetric mean sea surface models. Such models have two main uses in ocean studies: (a) when differenced from a geoid obtained from satellite perturbations one can recover features of the mean surface circulation with wavelengths greater than 4000 to 8000 km; (b) the mean sea surface itself is the most accurate geoid estimate at all shorter wavelengths, and has been successfully removed from individual altimetric passes to show mesoscale features. Three mean sea surfaces have been constructed by different groups: their formal error estimates are smaller than their differences, no estimate exists of the spatial structure of their errors, and color images show distinct error patterns. A second objective is to evaluate the possibility of extending the coverage of one oceanographic component of altimetric data to a certain width across its track, by using its correlation with sea surface temperature data,

imaged by AVHRR instruments aboard NOAA satellites. Approaches taken are: (1) to compute gravity accelerations from the mean sea surfaces using least squares collocation, then to compare altimetric and ship gravity along selected ship tracks known to be more accurate than average, and finally to compare power spectra of errors along ship tracks to images of the mean sea surfaces showing distinct error patterns; (2) optimal estimation of the altimetric field will be explored using an anisotropic covariance function derived from a temperature image coincident in time with the altimetric data. The principal investigator will devote half time to this task (and half to NASA's Ocean Data System). This RTOP also includes as a subtask -- the detailed design and management of the evolving computer network for the JPL Oceans group.

W87-70209 **161-80-41**
Jet Propulsion Laboratory, Pasadena, Calif.
EFFECTS OF A LARGE-SCALE WAVE-FIELD COMPONENT ON SCATTEROMETER-DERIVED WINDS
R. E. Glazman 818-354-7151

A common view of the sea surface as a two-scale system implies that the microwave scattering is governed both by small-scale roughness and by a large-scale component of the wave field that determines slopes of the rough facets. The small-scale roughness responds to an instantaneous local wind speed, whereas statistics of large-scale waves are sensitive also to wind fetch and duration. Effects of the large-scale component on scatterometer winds are the subject of the present research effort. The effort is necessitated by the fact that the algorithms employed to obtain scatterometer winds do not allow for possible variations of wind fetch and duration, thus raising questions as to the range of environmental conditions within which the measurements are reliable. Apart from direct applications, we seek a better understanding of the complex geometry of the random sea surface as pertains to problems of wind wave dynamics and surface scattering. The work will include theoretical investigations of the sea surface statistical geometry and re-examining SASS data to determine whether there exists a trend in scatterometer wind speed to be biased in the areas where wind fetch and duration are significantly different from the typical values characterizing experimental data sets employed in the development of the present empirical algorithms.

W87-70210 **161-80-42**
Jet Propulsion Laboratory, Pasadena, Calif.
LARGE-SCALE AIR-SEA INTERACTIONS
D. Halpern 818-354-5327

SASS winds, moored buoy winds, low-level cloud motion vectors, and rawinsonde soundings will address the following questions. Are the spatial and temporal scales of the surface wind field significantly different between the three equatorial oceans? What is the appropriate height of a low-level cloud motion vector? How does the shear between cloud winds and surface winds vary in the equatorial zone? Moored current and temperature measurements recorded in the upper ocean along the Pacific equator will be used to examine tropical phenomena influencing SST, South Equatorial Current, and Equatorial Undercurrent (EUC) dynamics. (1) What are the statistics and structures of upper ocean thermal and flow fluctuations? (2) In the generation, maintenance and dissipation of SST and upper ocean heat content variations, what are the relative roles of (a) horizontal and vertical currents, (b) adjustment of the zonal slope of the thermocline, (c) surface heat flux exchange, (d) equatorially trapped waves, and (e) entrainment and/or mixing? (3) Is the EUC confined to the thermocline, does the EUC rise to the surface, what happens to the EUC east of the Galapagos Islands, and how nonlinear are the dynamics of the EUC? (4) Is there a significant relationship between near-surface phytoplankton distributions and abundances and upper ocean thermal and flow fields in the eastern equatorial Pacific? Several pre-NSCAT and pre-TOPEX projects to be developed are: (1) use of SEASAT-A and GEOSAT altimetric data along the Pacific equator to examine the variability of the zonal gradient of sea level; (2) validation studies for ERS-1 and NROSS scatterometer winds; (3) use of satellite ocean color, wind, and SST data in an interdisciplinary study of eddy dynamics in the East China Sea; and (4) a ground truth NSCAT station at 0, 170W with the French.

W87-70211 **161-80-43**
Jet Propulsion Laboratory, Pasadena, Calif.
SPACE OCEANOGRAPHY
W. C. Patzert 213-354-4159

During the coming year, the primary activity will be to develop a scientific research plan to utilize satellite data to address oceanographic problems. The relationship of the future NSCAT and TOPEX/POSEIDON missions to the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean/Global Atmosphere (TOGA) program will be considered in this plan. Past research projects (pre-Headquarters) will be completed and prepared for publication in the referred oceanographic literature. Specifically, two past projects will be completed: (a) Analysis of satellite-tracked drifting buoy data from the NORPAX Hawaii/Tahiti Shuttle Experiment in the tropical Pacific Ocean will be finished. (b) A joint project with W. Broeker of LDGO on the exchange of waters through the SE Asian waters from the Pacific to the Indian Oceans will be completed. Assistance to the NSCAT and TOPEX Project scientists will be given if required and/or requested.

Tropospheric Air Quality

W87-70212 **176-10-04**
Goddard Space Flight Center, Greenbelt, Md.
SATELLITE MONITORING OF AIR POLLUTION
R. S. Fraser 301-344-9008

Continuation of this RTOP is contingent on a Headquarters review to be held in June 1986. The objectives are as follows: to make satellite measurements on a global scale of aerosol absorption, mass, transport, and trajectory; to develop algorithms to derive the above parameters from aircraft and satellite measurements of the radiance of sunlight scattered from the Earth atmosphere system; to apply the algorithms to aircraft measurements made near the Chesapeake Bay and satellite measurements of forest fire smoke, desert dust, and the Brazilian atmosphere; to validate such results with ground-based and independent aircraft measurements. The expected results are as follows: (1) Methods for estimating global transport of aerosol mass, its trajectory, size, and absorption from large sources such as urban-industrial pollution, forest fires, slash burning, and desert dust. (2) Specification of spectral bands for efficient measurement of the above parameters.

W87-70213 **176-20-99**
Ames Research Center, Moffett Field, Calif.
GLOBAL TROPOSPHERIC EXPERIMENT AIRCRAFT MEASUREMENTS
H. B. Singh 415-694-6769

The objective of this program is to provide atmospheric measurements aboard NASA aircrafts to support the science goals of the Global Tropospheric Experiment (GTE). The approach is to develop and test airborne instrumentation, integrate it on the aircraft platform (Electra, DC-8), operate it during GTE flights, provide data as required by GTE project office, analyze, interpret, and publish individual and/or collaborative results.

W87-70214 **176-30-01**
Jet Propulsion Laboratory, Pasadena, Calif.
KINETIC STUDIES OF TROPOSPHERIC FREE RADICALS
S. P. Sander 818-354-2625

A program of laboratory studies is underway to measure kinetic and photochemical parameters involving key free radical reactions in tropospheric chemistry. Attention will be focused on reactions involving methane, non-methane hydrocarbons and sulfur-containing species. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis,

discharge flow-mass spectrometry and discharge flow-Fourier Transform Infrared Spectroscopy.

W87-70215 **176-40-14**
Goddard Space Flight Center, Greenbelt, Md.
TROPOSPHERIC PHOTOCHEMICAL MODELING
R. S. Stolarski 301-344-9111

The objectives are to: (1) Develop a photochemical-transport model to simulate photoreactive trace gas distributions in the Earth's atmospheric boundary layer; (2) Use model to interpret observations made in ground- and aircraft-based measurements of trace chemicals and meteorological variables (winds, water vapor, temperature); (3) Adapt resulting model for use in global-scale photochemical models. The approach is as follows: (1) Investigation will focus on three case studies for which experimental results will be available for model verification: (a) the surface layer over land; (b) the clear sky planetary layer (PBL) over land and sea; (c) the marine PBL topped by stratocumulus clouds. (2) In each case an existing one-dimensional model will be modified to include a more refined description of photochemical kinetics and boundary layer transport. (3) Results from model simulations will be compared with measurements to be made in NASA's GTE and other programs. Expected results are as follows: (1) An improved understanding of chemical and dynamical interactions in the troposphere; (2) tropospheric models detailed enough to explain atmospheric observations but simple enough to be incorporated into more complex two and three dimensional models.

Solar Terrestrial and Astrophysics SR&T

W87-70216 **188-38-01**
Jet Propulsion Laboratory, Pasadena, Calif.
SOLAR AND HELIOSPHERIC PHYSICS DATA ANALYSIS
M. Neugebauer 818-354-2005

Solar-wind plasma and magnetic field data obtained by past and continuing space missions are used to address the following questions in heliospheric physics: (1) do tangential discontinuities (TDs) in the solar wind support surface waves? (2) what mechanism is responsible for the alignment of vector v and vector delta B across TDs in the solar wind? (3) what is the origin of clumps of TDs in the solar wind? The Solar Infrared Atlas task included in this RTOP in FY-86 will not be continued in FY-87.

W87-70217 **188-38-01**
Marshall Space Flight Center, Huntsville, Ala.
MODELING CORONAL STRUCTURE AND ENERGETICS
S. T. Suess 205-544-7611
(442-36-55)

Physical processes in the solar corona and interplanetary medium are being studied using three approaches: (1) a potential field model of coronal structure to analyze the magnetic interconnections between active regions, the corona, and the interplanetary medium; (2) a two-dimensional, numerical magnetohydrodynamic (MHD) model of coronal structure and analyze the force balance and characteristic velocities between 1.0 and 5.0 solar radii and to calculate model topologies using different geometrical forms for the photospheric magnetic field; (3) a magnetostatic model of sheared magnetic loops in a stratified atmosphere to study the equilibrium and stability of prominences; and (4) a one-dimensional, spherically symmetric, time-dependent numerical model of coronal flow with thermal conduction and energy source terms to analyze shocks in the presence of thermal dissipation and to test the stability of standing shock waves that have been shown to occur in solutions to the steady-state equations of motion. In addition to applying these four approaches, we will extend and further develop the models themselves. Finally, during these investigations, we will examine those related problems that make themselves evident as new results are produced. The motivation for this research is the opportunity to develop a physical understanding of the energetics and dynamics of coronal expansion into the interplanetary medium, including stationary and time-dependent phenomena, the characterization of the processes heating and accelerating the solar wind, and the topological structure of the expansion in three dimensions.

W87-70218 **188-38-51**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF SOLAR EXPERIMENTS AND HARDWARE
Stuart D. Jordan 301-344-8811

The objective of this RTOP is to develop scientific instruments which contribute to the solution of well-defined solar research problems. These activities have the ultimate objective of flying payloads on problem-oriented missions. These research programs will form the basis for missions using the Shuttle or free fliers. One of these will be a study of coronal structures contributing to the solar wind and the interplanetary plasma. A second will be a study of the sources of high energy particles of the Sun, emphasizing instrumentation not accommodated by the Solar Maximum Mission (SMM) and/or supplementary to the SMM instruments. A third will make high precision measurements of the solar diameter, to study long period resolution to the maximum possible extent. The instruments considered for these payloads are: (1) EUV and soft X-ray spectroheliographs and spectrographs for observations of structures in the corona and active regions with 1 arc sec spatial resolution and spectral resolution down to 10 mA; (2) High-resolution X-ray and gamma-ray telescopes; (3) A Solar Disk Sextant (SDS) to study solar pulsations. In general support of the programs for instrument development is the investigation of critical optical components for ultraviolet and soft X-ray wavelength studies. This covers: the design, fabrication, and testing of aspheric optical surfaces or Wolter Type-II grazing incidence telescopes, and extended definition studies for future solar instrumentation and evaluation of new optical and detector technologies that may be applicable to future solar EUV and X-ray observations.

W87-70219 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED OBSERVATIONS OF THE SUN
Stuart Jordan 301-344-8811

The major objectives of this program are as follows: (1) to obtain and analyze observations of solar velocity and magnetic fields, global oscillations and wave motion, coronal holes, active regions and flares, etc., at wavelengths observable from the ground which complement UV, EUV, X-ray and gamma-ray experiments on NASA flight missions such as the Solar Maximum Mission (SMM); (2) to support operational planning for spacecraft experiments; (3) to conduct basic research and develop specific instrumentation and observational progress relevant to objectives for future flight missions: (4) to analyze comet tail photographs to determine the velocity field of the solar wind and the three dimensional structure of interplanetary sector boundaries caused by the solar magnetic field; (5) to study the plasma structure apparent in wide-field photographs of comets Giacobini-Zinner and Halley in the context of results obtained in situ by the International Cometary Explorer (ICE) and by the suite of Halley probes. The Vacuum Telescope at Kitt Peak National Observatory is supported by the Laboratory through its Southwest Solar Facility. High-Resolution, full disk magnetograms and 10830A spectroheliographs are routinely obtained and substantial observing time is dedicated for special-purpose programs of spacecraft support and basic research by laboratory staff.

W87-70220 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
RESEARCH IN SOLAR VECTOR MAGNETIC FIELDS
M. J. Hagyard 205-544-7612
(188-38-53)

The objective of this research is a program of ground-based observations for basic research concerning solar vector magnetic fields and for support of NASA solar missions using the facilities of the Marshall Space Flight Center (MSFC) Solar Observatory. In the program of basic research, theoretical and observational

programs are undertaken to study vector magnetic field structures which are relevant to current problems in solar physics. To support future NASA solar programs, techniques of observation and of data reduction and analysis are developed using the MSFC vector magnetograph; such techniques will generate guidelines for operations of planned space-based magnetographs, and will provide more focussed direction for the research performed with these instruments. Support of ongoing NASA solar missions is provided through daily observations, transmission of magnetograms to PI's and other relevant personnel, and coordinated observing programs associated with collaborative investigations with mission PI's.

W87-70221 **188-38-53**
Marshall Space Flight Center, Huntsville, Ala.
STRUCTURE AND EVOLUTION OF SOLAR MAGNETIC FIELDS
Ronald L. Moore 205-544-7613

The general objective is to determine and understand basic empirical properties of solar magnetic fields, their effects in the solar atmosphere, and their generation within the Sun. The general approach is to analyze Marshall Space Flight Center (MSFC) vector magnetograms along with complementary data from other observatories and from solar space missions, and to interpret observed effects with physical models. The results will guide choices of specific observing programs for future solar space missions, including Sunlab, HESP, the XUV spectrometer/imager on SOHO, and HSRO (the revised Solar Optical Telescope). We will pursue the following studies: (1) Active regions: (a) form and action of the magnetic field in flares; (b) non-potential magnetic features, their formation, and their relation to enhanced heating and flaring; (c) emergence and submergence of magnetic flux; and (d) magnetic structure, heating, and dynamic phenomena in sunspots. (2) Quiet regions: (a) transition-region bright points and microflares; and (b) structure of the magnetic network and implications for the heating of the transition region and corona. (3) Solar cycle: (a) evidence in the sunspot record for bimodality of the solar dynamo; (b) X-ray bright points and fine-scale flux emergence; and (c) modeling of the solar dynamo.

W87-70222 **188-41-21**
Jet Propulsion Laboratory, Pasadena, Calif.
ASTRONOMY AND RELATIVITY DATA ANALYSIS
R. A. Preston 818-354-6895

The purposes of this research are to: (1) map the structure of extragalactic radio sources by Very Long Base Interferometry (VLBI) to study the astrophysics of these sources, and (2) analyze astrometric and radiometric data on the positions of the bodies of the solar system and analyze timing data on pulsars in order to test relativistic theories of gravitation.

W87-70223 **188-41-23**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
Theodore R. Gull 301-286-6184

Space based instrument systems for astronomy afford scientists important advantages which can not be fully utilized with ground based optical technology. In space, optical systems escape the detrimental atmospheric effects such as absorption and turbulence. This allows observations in previously unaccessible spectral ranges and the potential to measure ultra-faint and ultra-small objects. However, the technologies for space optics are fundamentally different from those in ground based systems. Technology developments for space optics specifically must address the expanded spectral region (X-rays to far-IR), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. We are presently conducting investigations in two technical areas that will have substantive emphasis on ultraviolet mirror coating developments that will have an impact on improved system throughput. In the area of diffraction grating technology, we are conducting studies of advanced design, fabrication, and testing methods. Specific applications include high and low resolution spectrographs and imaging spectrometers for the ultraviolet and extreme ultraviolet.

W87-70224 **188-41-24**
Goddard Space Flight Center, Greenbelt, Md.
ULTRAVIOLET DETECTOR DEVELOPMENT
Andrew Smith 301-344-8648

The objective of this RTOP is the development of a photon-counting detector suitable for future space astronomy missions such as LYMAN, second generation ST instrumentation, the Ultraviolet Imaging Telescope on ASTRO and various other Shuttle payloads. The detector will be sensitive to far ultraviolet wavelengths, has a large format and high resolution. The design is exceedingly flexible, so that once the concept has been approved, future detectors can be optimized for particular missions. The detector consists of an image converter/intensifier module fiber-optically coupled to a mosaic of charge coupled devices (CCD's) which provide digital readout. The photocathode may be deposited either on a faceplate in front of a large microchannel plate (MCP) intensifier or directly on the input side of the MCP. The output from the MCP is proximity focussed onto a phosphor screen on a fiber-optic plate, which provides the input to the fiber-optic coupler. The coupler module consists of a 2 x 2 array of fiber-optic tapers, each of which is coupled to a single CCD. The CCD's are read out in parallel. A prototype consisting of a 25 mm MCP coupled to a single fiber-optic taper and CCD has been fabricated and is being tested. The experience gained in fabrication is being fed back into the development program.

W87-70225 **188-41-53**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF GALAXIES. THE INTERSTELLAR MEDIUM. MOLECULAR CLOUDS, STAR FORMATION
B. F. Smith 415-694-5515

The objective of this RTOP is to conduct theoretical studies on fundamental phenomena associated with continuum spectra, dynamics, and line spectra in active galactic nuclei, the formation and evolution of galaxies and clusters, random luminosity fluctuations in compact astrophysical objects, molecular cloud formation and evolution, star formation and infrared emission in interstellar shocks. A large fraction of this effort involves computational astrophysics employing a wide variety of numerical codes developed at Ames to treat multidimensional hydrodynamic and magnetohydrodynamic fluid problems, with multidimensional particle problems, and complex radiative transfer problems

W87-70226 **188-41-57**
Ames Research Center, Moffett Field, Calif.
LABORATORY STUDY OF CHEMICAL AND PHYSICAL PROPERTIES OF INTERSTELLAR PAHS
L. J. Allamandola 415-694-6890

It has recently been proposed that free molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects and thus a widespread, but previously unrecognized, component of the interstellar medium which could play a dramatic role in many processes such as energy balance, molecular cloud collapse and dust particle formation. Testing of this hypothesis and its impact on the large astrophysical picture is severely hampered by a general lack of knowledge of the spectroscopic, physical and chemical properties of PAHs in the forms they are likely to be in space: ions, radicals, neutral species and clusters. Spectroscopic properties of these unique species are particularly important to know since virtually all observational data pertaining to this problem is spectroscopic in nature. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further our understanding of their potential role in astrophysics. Experiments will be performed in the laboratory in which the PAHs to be studied are prepared

under conditions which duplicate, as much as possible, the interstellar conditions in which they are found.

W87-70227 **188-46-01**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)
Lawrence J. Caroff 415-694-5523

This research effort seeks to understand the origin of the continuum spectra of Quasi-Stellar Objects (QSOs) and other Compact Luminous Objects. An optically thick, relativistic outflow is postulated to arise in the central core of these objects and arbitrary input energy spectrum of photons and/or electron-positron pairs is assumed. The evolution of the energy distribution functions of the photons and pairs is followed until either (1) the system becomes optically thin, or (2) thermal equilibrium sets in. At that time the emerging spectra are compared with observations. Interaction processes which are likely to be important to the spectral evolution are: pair-production, annihilation, Compton scattering, Bremsstrahlung, Coulomb scattering, and, if a magnetic field is present, synchrotron/cyclotron emission.

W87-70228 **188-46-57**
Marshall Space Flight Center, Huntsville, Ala.
GAMMA RAY ASTRONOMY AND RELATED RESEARCH
G. J. Fishman 205-544-7691

An observational program in gamma ray astronomy and cosmic ray research is being pursued using balloon-borne experiments. Techniques and instrumentation for future space flight experiments are developed concurrently. The following are the objectives of the MSFC research program: (1) To perform new scientific observations in gamma ray astronomy and cosmic ray physics within the limitations of current balloon flight capabilities. (2) To develop new detectors and experimental techniques for future space-borne, gamma ray astronomy, and high-energy cosmic ray observations. (3) To study various sources of background radiation, primarily atmospheric gamma ray radiation and activation of detectors and materials in order to increase the sensitivity of gamma ray observations.

W87-70229 **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY ASTRONOMY
Carl E. Fichtel 301-286-6281

The technical objective is to develop the most appropriate detector systems for the observation of astrophysical sources of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system are still being pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma-ray observations. In the high energy region improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons. Improved attitude and aspect systems are being built. In the 1/2 to 40 MeV region different interaction processes become dominant and hence, new detector techniques are required. A totally new detector has been developed. It is based on the Compton interaction process, but includes several new concepts which should increase the sensitivity by a factor of ten. For gamma-ray burst studies other wavelengths are being investigated. In particular a ground-based system is being developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma-ray bursts.

W87-70230 **188-46-59**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY ASTRONOMY
E. A. Boldt 301-286-5853

Celestial X-ray sources have introduced us to rich new aspects of astronomy ranging from the millisecond bursts of hard X-rays coming from the innermost orbits of matter falling into a black hole to the diffuse emission from extensive hot plasmas associated with clusters of galaxies. The combination of large sensitive area, low detector background, high temporal resolution and energy-dispersive spectroscopy over a broad band-width has been our approach in discovering and exploring these phenomena. The power of this approach has been well demonstrated. Extending it with improved spectral resolution and broad-band imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise detectors of optimum energy resolution, large area X-ray concentrators and imaging devices.

W87-70231 **188-48-52**
Ames Research Center, Moffett Field, Calif.
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-694-4164

The general objective of the proposed research is to undertake a unified theoretical analysis of the problem of star formation. Solid achievement is likely to come, however, only with a healthy awareness of constraints placed on theoretical ideas by the ever increasing data base. Moreover the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. Our comprehensive investigation includes studies of patterns of star-forming regions on galaxy wide scales; dynamics, structure, energetics, and chemistry of the interstellar medium; details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; possible differences in the formation of high and low mass stars; formation and evolution of protostars and nebular disks; mechanisms of planetary system formation and disk dispersal; and the origin of bipolar flows and their effect on the surrounding gas and dust.

W87-70232 **188-78-46**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ASTROPHYSICS MAGNET FACILITY
William D. Hibbard 301-286-7510

The objective of this RTOP is to provide science support, system planning and a conceptual engineering design for a superconducting magnetic spectrometer, tentatively called Astromag, that will fly as an attached payload on the space station. It will permit study of the properties of cosmic rays in order to understand their history as a sample of non-solar material, and their nucleosynthesis, acceleration, and transport in and effects on the galactic magnetic fields. It will also permit studies of the antiprotons observed recently in cosmic rays, and antimatter searches 100 to 1000 times more sensitive than previously possible. Astromag will be designed for space servicing, including maintenance, cryogen resupply and exchange of experiment instrumentation. The approach is to conduct preliminary design trade-off studies leading to a feasible, economical facility concept. The studies will be carried out by the Particle Astrophysics Magnetic Facility Definition Team, supplemented by the GSFC Advanced Missions Analysis Office. The products will be reliable cost and schedule estimates, risk assessments, feasibility demonstration and the identification of long-lead items, safety concerns and reliability approaches.

W87-70233 **188-78-60**
Jet Propulsion Laboratory, Pasadena, Calif.
ASTROPHYSICAL CCD DEVELOPMENT
S. A. Collins 818-354-7393

Charge Coupled Devices (CCDs) are being developed for use as camera/spectrograph detectors throughout an unprecedented spectral range: 1-10,000 A. The objective of this task is to implement and demonstrate CCD design modifications which enhance CCD performance at X-ray and ultraviolet wavelengths. Specifically, good detection efficiency ($>$ 30%) is to be achieved throughout the range of 1-4000 A, and low readout noise ($<$ 5 electrons/pixel, rms) is to be demonstrated. Our approach is to contract for modification of the design of an existing visible-light

CCD, to procure such enhanced CCDs to evaluate their performance at low signal levels, and to undertake additional design/fabrication iterations as required to achieve the stated objectives.

W87-70234 **188-78-62**
Marshall Space Flight Center, Huntsville, Ala.
GRAVITY PROBE-B
A. K. Neighbors *205-544-0565*

Gravity Probe-B is a free flying spacecraft which will confirm Einstein's General Theory of Relativity by measuring the relativistic precession of ultra precise gyroscopes. The work is a coordinated theoretical, experimental, engineering project with MSFC having overall project management responsibility. Drawing on a broad experience base consisting of technology development, definition studies, tests, and analyses, a contract with Stanford for the first 21 months of the Engineering Development was signed in March 1985. The Engineering Development will culminate in the launch of a Shuttle flight test experiment in FY92 and the beginning of the Science Mission development in FY90.

W87-70235 **188-80-02**
Goddard Inst. for Space Studies, New York.
RESEARCH IN ASTROPHYSICS: SOLAR SYSTEM, TURBULENCE
V. Canuto 212-678-5571

The objectives of this program are the study of the phenomenon of Large Scale Turbulence (LST) and its implications in astrophysics. The great diversity of physical settings (geophysics, atmospheric physics, origin of planets, accretion disks in genera, molecular clouds, etc.) in which a detailed knowledge of turbulence is needed, is in stark contrast with the lack of an analytical model sufficiently general to be applicable to the above cases. Since the only available methods are either phenomenological expressions or numerical simulations of the full hydrodynamic equations, (neither of which is satisfactory), we have had as an objective that of constructing an analytical model for LST. The approach uses as the only ingredient for both the energy source as well as for the cascade integral the growth rate of the unstable modes that ultimately generate turbulence. The results thus far (for the particular case of convective turbulence) fare very satisfactorily with laboratory data for Rayleigh numbers up tp 10(11).

Planetary Astronomy

W87-70236 **196-41-30**
Marshall Space Flight Center, Huntsville, Ala.
INFRARED IMAGING OF COMETS
C. M. Telesco 205-544-7723

The objective of this RTOP is an observational program using detector array instruments for infrared imaging of comets. (1) An existing infrared array camera containing 20 bolometer detectors will be used to study the large-scale spatial distribution of infrared emission in comets in the wave-length region from 10 micrometers to 30 micrometers. These observations will be performed from ground-based infrared observatories. (2) An additional infrared system with an InSb detector array spanning the wavelength region 1 micrometers to 5 micrometers is now under development. Beginning in the second half of FY87, observations with this instrument will importantly complement those obtained with the bolometer array.

W87-70237 **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED INFRARED ASTRONOMY
Donald E. Jennings 301-286-7701
(188-41-55; 154-50-80)

The scientific objective is to determine information on astrophysical objects, such as molecular clouds, interstellar lines, molecular and circumstellar components in stellar atmospheres, and planetary atmospheres from high spectral resolution ground-based measurements in the intermediate infrared. An observing program employing Michelson Fourier transform spectrometers meets the simultaneous requirements of high spectral resolution, a wide free spectral range and high sensitivity. Spectral resolutions up to .01 cm(-1) are achieved in the 500 to 2000 cm(-1) range. A post-disperser detection system has been used to reduce background noise from a warm telescope and instrument system and the atmosphere at the detector; thus allowing the multiplex advantage of the interferometer to be retained. Cooled or warm FTS instrumentation with the post-dispersed detection system allows maximum sensitivity to be attained at a ground-based site. The sensitivity level for a measurement in the 1000 cm(-1) region with a 122 cm diameter telescope, an integration time of 60 minutes and a spectral resolution of 0.2 cm(-1) is approximately 5 x 10(-26) Watts/m2/Hz. Observations of Jupiter at 12 microns during December 1985 show excellent sensitivity on ethane lines at 0.01 cm(-1) resolution.

W87-70238 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
PASSIVE MICROWAVE REMOTE SENSING OF THE ASTEROIDS USING THE VLA
W. J. Webster, Jr. 301-286-5554

We intend to infer structure and composition parameters for a selected set of the ten physically largest asteroids by employing microwave remote sensing techniques originally developed for Earth observations. Precise flux density measurements made with the Very Large Array (VLA) of the National Radio Astronomy Observatory will be used to define the microwave continuum spectra of these asteroids. These spectra will be inverted in order to estimate the near-surface bulk properties (radii, roughness, composition) independent of previous optical or infrared spectroscopy.

W87-70239 **196-41-54**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED INFRARED ASTRONOMY AND SPECTROSCOPIC PLANETARY DETECTION
M. J. Mumma 301-286-6994

The objectives of this RTOP are twofold. First, we will study the molecular constituents of solar system objects (e.g., planetary atmospheres and comets) through observations of their IR line spectra. High spectral and spatial resolution is utilized in order to obtain information on spatially localized phenomena and on dynamical processes (e.g., winds in planetary atmospheres). The approach is to develop and utilize laser heterodyne spectrometers for ultra-high spectral resolution in the mid-infrared (8 to 30 micrometers), and to utilize Fourier transform instrumentation in the near infrared (lambda $<$ 8 micrometers). These techniques provide optimum sensitivity, resolution and spectral stability needed for problems such as mapping the excitation conditions and outflow velocities in cometary comae. Observations are conducted from ground-based observatories and from the Kuiper Airborne Observatory. The second study is directed towards extending our knowledge to planetary systems which may exist around other solar-type stars. The underlying principle is that such extra-solar planetary systems could be detected by measuring the small Doppler reflex which planetary orbital motion produces in the spectrum of the parent star. The objective of this task is to validate such an approach by measuring the velocity stability of integrated sunlight. Solar cycle related effects which are observed are compared to the 13 meter/sec Doppler reflex induced by the orbit of Jupiter, and prescriptions are developed for separating these effects so that planetary Doppler signatures can be identified in stellar spectra. In order to obtain great spectral stability, the observational approach is to use Fourier transform and laser heterodyne spectrometers in the infrared spectra region.

W87-70240 **196-41-67**
Ames Research Center, Moffett Field, Calif.
PLANETARY ASTRONOMY AND SUPPORTING LABORATORY RESEARCH
F. P. J. Valero 415-694-5510

The composition of planetary and cometary atmospheres and

surfaces and the abundance, temperature and pressure of certain atmospheric constituents can be determined by spectroscopic observations from ground-based and airborne observations. Such data are necessary for the preparation of valid model atmospheres, which are needed to evaluate the possibilities of life on the planets, to design systems for exploratory missions and for the preparation of evolutionary models of planetary interiors. The objectives of this work are to obtain, study and analyze spectroscopic observations of comets, planets and their satellites; to obtain and analyze, in the laboratory, spectra appropriate for valid interpretation of the observations; and to develop the analytical and computational techniques necessary to interpret the observational spectra in terms of real planetary atmospheres and surfaces, and cometary gases and ices. The objective will be pursued in measuring, in the laboratory, basic molecular parameters such as basic band modeling parameters, absorption line half-widths, vibration-rotation interaction constants, and line pressure induced shifts and absorption in the gas phase as well as absorption band profiles and intensities for these molecules condensed as ices.

W87-70241 **196-41-68**
Ames Research Center, Moffett Field, Calif.
DETECTION OF OTHER PLANETARY SYSTEMS
J. D. Scargle 415-694-6330

The long-range objective of this activity is to develop a comprehensive program to detect other planetary systems. The near-term objectives include the funding of selected University researchers to pursue modest exploratory developmental and observational programs as well as theoretical studies directed at identifying optimum techniques for both space-based and ground-based planetary detection systems. The choice of University researchers will be based on a peer review of unsolicited proposals, and it will be guided by the basic recommendations set forth in Volume I of NASA CP-2124. Funding will also be used to support in-house theoretical research at Ames Research Center related to the detection and study of other planetary systems.

W87-70242 **196-41-71**
Jet Propulsion Laboratory, Pasadena, Calif.
OPTICAL ASTRONOMY
J. T. Trauger 818-354-8875

The overall objective of this ground-based optical astronomy task is the physical study of atmospheres and magnetospheres of planets, satellite atmospheres and surface phenomena, and comets by means of ground-based astronomy at UV, visible, and IR wavelengths. This RTOP consists of several subtasks: (1) Planetary Spectroscopy, to investigate the physical and chemical properties of the atmospheres of planets and satellites; (2) Planetary Fabry-Perot Spectroscopy, to study the composition, structure, chemistry, and origins of planetary atmospheres through Earth-based high-resolution Fabry-Perot spectroscopy; to study electron-excited forbidden emissions from Jovian magnetospheric ions with CCD imaging photometry from which a detailed description of the evolution and physical character of the Jupiter/Io nebula can be derived; and to study velocity structure and dynamics of the gaseous envelopes of comets and Io with high spectral resolution (Doppler velocity resolved) Fabry-Perot/CCD imaging techniques; (3) Infrared Observations of Outer Planet Satellites, to investigate the thermophysical properties of outer solar system satellites through ground-based thermal IR photometry; (4) Volatiles in the Surfaces of Icy Satellites, to study the composition of surface ices on the outer planet satellites with a cooled grating/InSb array instrument for near-IR spectroscopy; and (5) TMO Support to Other Programs, to provide limited operational support (equipment maintenance and setup, observing assistance) at Table Mountain Observatory (TMO) for programs supported from other RTOPs, principally supporting the asteroid dynamics task under A. Harris (JPL).

Life Sciences SR&T

W87-70243 **199-11-11**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION EXERCISE COUNTERMEASURES
J. S. Logan 713-483-4731
(199-11-31)

The Space Station Countermeasures RTOP may be divided into three function areas: (1) exercise protocol definition (or prescription); (2) Identification and testing of candidate technologies; and (3) definition and feasibility studies for exercise incentive technologies. Funding, as per previous agreements between JSC Space and Life Sciences Directorate and NASA/HQ Life Sciences Division, will be utilized for definition of requirements and candidate systems. Prototype hardware and flight hardware will be funded by the Space Station Program Office. Formulation of exercise protocols, or an exercise prescription is required prior to preliminary definition of candidate exercise hardware. Initial work is ongoing to evolve this exercise prescription, however, completion of this effort requires input from the Exercise Advisory Committee. (Advisory workshop is scheduled for June 1986 and was funded by the FY-86 Space Station Countermeasures RTOP). It is mandatory that the exercise protocols be completed during FY-87 so that system hardware development can proceed in a timely manner. Additionally, it is mandatory that this prescription be validated in on-orbit testing. This will require the capability to collect, process, and downlink exercise/physiologic data.

W87-70244 **199-11-21**
Lyndon B. Johnson Space Center, Houston, Tex.
LONGITUDINAL STUDIES (MEDICAL OPERATIONS LONGITUDINAL STUDIES)
Edward C. Mosely 713-483-4264

Objectives of the research in this area is to conduct longitudinal retrospective and prospective studies of medical data from astronauts, a control group of civil servants, and other JSC employees. The studies covered involve individuals in a relatively closed population in an attempt to relate changes in physiology and/or pathology to specific factors associated with individual traits of the astronauts and occupational exposure. Areas of study and particular interest consists of acute responses and long-term adaptive mechanisms to weightlessness, changes observed in complete annual physical examinations, and the effects (if any) of the occupational exposures of crewman to the aging processes and disease incidence. The approach includes (1) input and storage of all astronaut medical exams (annual, flight, and illness exams) in computer databases, (2) collecting and storing similar information on a control group of civil servants (matched on age, sex, body size and smoking history) and other civil servants, (3) analysis of the longitudinal information comparing these groups, and (4) cumulative evaluation of pre/postflight physiological changes across missions, (5) periodic reviews to include new parameters.

W87-70245 **199-11-31**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION HEALTH MAINTENANCE FACILITY
J. S. Logan 713-483-4731
(199-11-11)

Current space station mission scenarios describe a 90-day mission for a 6 to 14 person crew in low Earth orbit. The space shuttle will be the only means of transportation to and from the station and will visit the station only during the initial and final phases of a mission. The time required to accomplish a rescue for a medical contingency will be 14 to 28 days from the time the decision to rescue is made. The cost of a rescue mission is estimated to be $150 million dollars. The Medical Sciences Division at Johnson Space Center is in the early stages of requirements and systems definition for a modular inflight medical system known as the space station Health Maintenance Facility (HMF) which will provide preventive, diagnostic, and therapeutic capabilities. The goals of the HMF are: (1) to ensure the health and safety of the crew; (2) prevent an unnecessary rescue; and (3) to increase the

probability of success of a necessary rescue. HMF requirements derive from the operational constraints such as weightlessness, previous inflight medical experiences, and the projected risk of medical/surgical contingencies. The unique challenge of providing medical coverage for space station requires the development of low weight, low volume, highly automated medical hardware having wide application to terrestrial medical care.

W87-70246 **199-11-34**
Jet Propulsion Laboratory, Pasadena, Calif.
ULTRASOUND DETECTION OF BENDS
J. A. Rooney 818-354-3942

The basic objective is the development of swept-frequency ultrasonic techniques that are capable of quantifying the onset or development of decompression sickness in NASA flight personnel. The specific objectives include (1) development, characterization and optimization of swept-frequency ultrasonic techniques utilizing transmission, reflection, harmonic and phase-detection technologies to exploit resonant properties for quantification of bubbles in biological systems, (2) determination of the necessary design parameters for an ultrasonic system for imaging and quantifying bubble populations and dynamics, (3) determination of the acoustic parameters of bubbles in biological systems in the size range of interest to NASA investigators, (4) determination of the feasibility of utilizing swept-frequency ultrasonic systems for quantifying bubble dynamics and bubble population interactions, and (5) development of, in collaboration with other NASA investigators, the basic design criteria for ultrasonic techniques for use in studies and monitoring of decompression sickness. The objectives will be met by the modification and development of the unique JPL swept-frequency ultrasound system. Transmission, reflection, harmonic and phase-detection techniques will be developed and compared for sensitivity and resolution. Measurements will be made of the acoustic parameters of bubbles needed both for quantification of their population statistics and for determining future system design parameters. Theory will be modified to describe bubbles in biological media in the size range of interest. Consultations and collaborations with investigators at JSC will be developed and used to determine desired system parameters.

W87-70247 **199-11-34**
Jet Propulsion Laboratory, Pasadena, Calif.
IN-FLIGHT DIAGNOSTIC SENSORS
S. L. Prusha 818-577-9594

The purpose of this study is the development of subsystem requirements for a series of chemical sensors to be used for biochemical analysis for studies in aerospace physiology. The sensors will emphasize solid state design and will be designed for integration into the space station or shuttle environment. The requirements will be determined after technology assessments and system requirements are completed, which was addressed in a previous RTOP. FY87 plans will include chemical sensor subsystem requirements definition, environmental constraints definition, existing sensor integration and modification assessment, and the start of conceptual and subsystems designs. Work will be conducted in collaboration with university based researchers, with the nature of the work and specific arrangements to be determined. The ultimate product resulting from this work will be a flight qualified system used for in-flight biochemical analysis. Used in conjunction with other existing and proposed diagnostic instruments, this will provide for a comprehensive array of diagnostic tools for in-flight evaluation of the effects of human exposure to the space environment.

W87-70248 **199-12-51**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE ADAPTATION SYNDROME
F. A. Kutyna 713-483-2381
(199-22-22)

Manned spaceflight has demonstrated that the Space Adaptation Syndrome (SAS) is unpredictable and may be variable among individuals. Up to 50% of Shuttle crewmembers experience symptoms of space motion sickness which can persist through the first 2 to 4 days of the flight. Thus, on short duration Shuttle flights a significant portion of the mission time may be sent with some crewmembers affected by symptoms of SMS. The program outlined by this RTOP is directed specifically towards understanding and resolving the problems caused by SAS. These problems, which arise from the rearrangement of sensory motor interactions during exposure to 0-g, impair operational efficiency and the health and safety of astronauts and other crewmembers. The goal of this program is to understand the underlying causes of SAS in order to develop effective and operationally useful countermeasures. The major objectives are: (1) to conduct research which leads to a better understanding of the underlying mechanisms of SAS and fully develop effective and operationally useful preflight and inflight countermeasures, (2) to develop reliable criteria for determining susceptibility to SAS, and (3) to develop techniques to minimize reentry phenomena and to facilitate readaptation to 1-G. The approach will be to conduct an interrelated series of operationally oriented ground-based and space-flight studies designed to address one or more of the above objectives in the area of pharmacology, neurohumoral and biochemical correlates, adaptation techniques, psychophysiological studies and visual-vestibular studies. Human subjects will be used primarily. New facilities, hardware and measurement procedures will be developed as required.

W87-70249 **199-13-40**
Langley Research Center, Hampton, Va.
VIBROACOUSTIC HABITABILITY/PRODUCTIVITY
D. G. Stephens 804-865-3577

Some objectives are to develop the methodologies of vibroacoustic prediction, vibroacoustic criteria, and control procedures for use in the design and operation of a space station to ensure high levels of habitability and productivity. The task will provide the technology for the program developed as part of the Human Productivity Program Definition*. The control of vibroacoustic exposure requires technology developments in the following areas: (1) Develop and/or validate methods for predicting the level, frequency, and time history of the noise at each location within the space station where human activity takes place. The models shall include: The source noise levels of equipment; volume of the modules; absorption characteristics of interior surfaces; and structural noise transmission properties of the configuration. (2) Develop and/or validate vibroacoustic exposure methodology (criteria) which includes hearing, speech, communication (aided), performance; comfort, and sleep. (3) Development model for use in controlling the levels of vibroacoustic exposure to meet vibroacoustic criteria within the various constraints of the Space Station design. Such models shall be suitable for trading off the effectiveness of source control, control through quiet operating procedures, interior treatment and/or design, crew utilization. * Cramer, D. B.: Space Station Task Force--Human Productivity Program Definition.

W87-70250 **199-13-41**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACECRAFT ENVIRONMENTAL FACTORS
J. M. Waligora 713-483-2381

The objective of the Environmental Factors RTOP is to support reach involving specification, measurement, and control of the man-made internal environment in the manned spacecraft. Major emphasis will be in atmosphere selection and verification, and detection and control of toxic and microbiological contamination as it impacts the cabin atmosphere and the potable water supply. A second objective is to support research to study the response of the body to deleterious levels of environmental factors that may be encountered inflight to allow prediction of physiologic or pathologic response and to prevent or ameliorate this response. The approach utilized to accomplish these objectives will be to sponsor in-house and outside contractual studies which are required to define requirements for spacecraft environmental factors, to provide the technology to detect compliance with these requirements, to actively control to these requirements primarily by removal of contaminants, and finally, to define the mechanism of response

of the body to deleterious environmental factors and investigate potential countermeasures.

W87-70251 **199-21-11**
Lyndon B. Johnson Space Center, Houston, Tex.
CARDIOVASCULAR RESEARCH (JSC)
J. B. Charles 713-483-2381

The overall objective of this program is an understanding of the cardiovascular changes (the Cardiovascular Readaptation Syndrome) which occur with space flight and their impact on crewmembers. Specific aims are to: (1) define the underlying mechanisms of cardiovascular readaptation; (2) provide appropriate countermeasures for these effects; (3) develop systems to aid in accomplishing these goals; and (4) apply the results to the selection, retention and health maintenance of future space travellers. Ground based studies on both human and animal subjects will in part utilize (1) provocative techniques such as lower body negative pressure and exercise testing, (2) bed rest studies as analogs to weightlessness, (3) noninvasive and invasive cardiovascular monitoring, and (4) pharmacologic interventions, all in an effort to accomplish the goals set forth above. Direct inflight applications or continued research will be performed as required. Impact will be greater access to the space flight environment for more diverse segments of the population under a greater variety of conditions.

W87-70252 **199-21-12**
Ames Research Center, Moffett Field, Calif.
CARDIOVASCULAR PHYSIOLOGY
H. Sandler 415-694-5745

The overall goal of this program is an understanding of the cardiovascular/fluid-electrolyte changes occurring with spaceflight. Specific aims are to: (1) define underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short- and long-term weightlessness exposure; (3) develop appropriate countermeasures for observed changes; (4) improve selection criteria for passengers and crew; and (5) develop and implement appropriate spaceflight experiments. To accomplish this goal, ground-based studies on both human and animal subjects will be carried out. Specific activities will include: (1) determining effects of exercise training; (2) exposing humans to horizontal and head-down bed rest and water immersion; and (3) test procedures, devices and drugs to prevent and counteract deconditioning. Results should lead to: (1) a better understanding of mechanisms of cardiovascular deconditioning; (2) better devices and procedures for modifying deconditioning effects; and (3) specific spaceflight experiments. Results of proposed studies will improve flight safety and understanding of spaceflight risks. They will also provide access to flight of a broader segment of population, and will use weightlessness to expand our understanding of cardiovascular/fluid-electrolyte function.

W87-70253 **199-21-51**
Lyndon B. Johnson Space Center, Houston, Tex.
ENDOCRINOLOGY AND PHYSIOLOGICAL CONTROL (HEMATOLOGY, ENDOCRINOLOGY, AND NUTRITION)
Nitza M. Cintron 713-483-5457
(199-21-10; 199-22-31)

The absence of hydrostatic forces, which results in body fluid shifts, and the absence of deformation forces on normally load-bearing tissues, are postulated to cause the principal disturbances found during and after space flight in the fluid and electrolyte, cardiovascular, erythropoietic, musculoskeletal, and metabolic systems. These alterations result in a multitude of physiological imbalances such as a reduced body fluid volume with concomitant losses of electrolytes, loss of body calcium stores, skeletal muscle atrophy, and a negative energy balance after prolonged space flight. The purpose of the present program is to study and define, at the cellular, biochemical, and endocrine levels, key elements underlying the identified physiological responses to space flight which allow the definition and assessment of crew health status and which reveal areas of countermeasure development. Results of the individual research investigations are anticipated to provide an enhanced understanding of the effects of weightlessness on man and his readaptation to the Earth environment. Using principally model systems in human clinical research, investigations will be directed toward the identification and study of biochemical and neurohumoral agents which are active in the various adaptive phases of space flight.

W87-70254 **199-21-52**
Ames Research Center, Moffett Field, Calif.
HEMATOLOGY, IMMUNOLOGY AND ENDOCRINOLOGY
A. D. Mandel 415-694-5061

The purpose of this RTOP is to address the endocrinological, hematological, and immunological changes that accompany spaceflight. It will also assess the clinical significance of such changes and seek ways of preventing or treating adverse effects of prolonged space flight, which have been shown to influence parameters of the immune response. This research will be accomplished by using a rat suspension model to provide effects similar to space flight. Quantitative and functional behavior of immune parameters can then be extrapolated to predict the infectious disease hazard of space flight. This program will terminate at end of FY 1986.

W87-70255 **199-22-22**
Ames Research Center, Moffett Field, Calif.
NEUROPHYSIOLOGY
N. G. Daunton 415-694-6245
(199-12-51)

Significant changes occur in the way the Central Nervous System (CNS) processes sensory inputs and programs motor outputs during adaptation to the micro-gravity environment of space, and during re-adaptation to Earth's gravity. These changes in CNS processing result in space motion sickness, perceptual illusions, performance deficits, and postural control deficits, all of which impair the operational efficiency of astronauts, especially during the first 3 - 5 days of exposure to micro-gravity and re-exposure to Earth's gravity. It is not known whether the changes in CNS structure and function will be reversible after long-term (years) exposure to micro-gravity. The overall objective of this program is to identify CNS components and mechanisms underlying the process of adaptation/re-adaptation to altered gravitational conditions so that the consequences of long-term, as well as short-term, exposures to micro-gravity on the CNS can be determined. The general approach to understanding these components and mechanisms involves identifying in both ground and flight investigations the functional changes which occur during adaptation to altered-gravity environments and then determining the neurophysiological, neurochemical, and structural changes in the CNS which underlie the functional changes. With this knowledge, countermeasures can be developed to minimize specific problems and to ensure the productivity, health, and safety of astronauts in space and on return to Earth.

W87-70256 **199-22-31**
Lyndon B. Johnson Space Center, Houston, Tex.
BONE PHYSIOLOGY
V. S. Schneider 713-483-2381
(199-21-51)

The regulation of musculoskeletal integrity and function during space flight and the causes of bone's apparent demineralization and dissolution are central questions addressed by the present research program. We intend as outlined in the FASEB reports on muscle and bone to elucidate and define the mechanisms operative in the processes associated with calcium metabolism and bone loss during weightlessness, to determine the interrelationship between muscle and bone physiology, to develop methods to assess changes in bone and muscle more accurately by non-invasive means, and to develop effective countermeasures to these potential deleterious skeletal changes in order to optimize crew's performance and recovery upon return to a one-g environment. Clinical human and animal models will be used to define the mechanisms underlying bone and muscle mass regulation and loss during space flight. The focus will be on the

biochemical, endocrinological, and physico-mechanical levels of function. Preventive and remedial countermeasures will center primarily around mineral supplementation, drug administration, diet modification, and physical manipulation.

W87-70257 **199-22-32**
Ames Research Center, Moffett Field, Calif.
BONE PHYSIOLOGY
S. B. Arnaud 415-694-6561
(199-40-32)

The overall goal of the Bone Physiology Program is to advance our knowledge of the causes and mechanisms of the immediate and delayed effects of spaceflight on skeletal and calcium metabolism in man and animals in order to form a rational basis for their prevention. Short term goals are focused on one of the four recognized problems which occur during weightlessness; demineralization of bone. This may or may not be the direct consequence of the other three documented changes in calcium metabolism in astronauts: negative calcium balance, modest increases in circulating calcium and phosphorus, and calciuria. Goals can be approached through research projects, involving animal and human subjects, that emanate from a variety of disciplines in both basic science and clinical medicine. Every opportunity for coordinated studies with flight material is sought to validate ground-based human and animal models for weightlessness. These models can range from whole animals immobilized to simulate hypogravity to cell culture systems developed to pinpoint the cellular response to chemical or biochemical alterations in a space environment. These experiments form the data base for predicting the physiologic effects of long term spaceflight, and for developing the countermeasures needed to ensure the health and productivity of people who will reside in and travel to and from space.

W87-70258 **199-22-34**
Jet Propulsion Laboratory, Pasadena, Calif.
BONE LOSS
S. L. Manatt 818-354-4256

This program seeks to develop the best approaches and instruments for in vivo bone mineral measurements that best satisfy NASA's needs and to carry out studies of the extent and mechanism(s) of bone mineral changes due to zero-g and immobilization. This task consists of two components. The first is a research contract with the Medical School, University of California at San Francisco (UCSF), for development of a new type CT system for bone mineral measurements and the testing of the latter instrument. From the performance of a prototype system with one Gd-153 source and a limited detector array, a proposal for the second stage of development of the full system received AIBS approval, and this prototype instrument is being assembled for delivery to JSC in May 1987. The second component involves studies with a small gamma-ray scanner at JPL with the capability for investigations, both in the CT and absorptiometry modes of operation, of phantoms and standard samples. These latter will be used in the tests of accuracy and precision of the instrument being assembled at UCSF. The potential application of the small JPL scanner for small animal and plant material studies will be evaluated. Interest in these applications of this scanner has been expressed by Livermore Lab and Vestar Research, Inc. The potential of NMR imaging and other NMR techniques for obtaining new fundamental information on bone mineral biochemistry will receive some consideration.

W87-70259 **199-22-42**
Ames Research Center, Moffett Field, Calif.
MUSCLE PHYSIOLOGY
R. E. Grindeland 415-694-5756
(199-40-32)

The overall aims of this research program are to determine the underlying causes for the muscle atrophy problem observed in both humans and animals in space and to develop suitable countermeasures. Specific objectives consist of: (1) determining the rate and extent of atrophy and recovery from atrophy, (2) conducting basic studies into the nature of the biochemical and physiological mechanisms which regulate skeletal muscle mass and function, (3) developing and validating methods for monitoring atrophy of skeletal muscle in human subjects and laboratory animals, and (4) investigating possible countermeasures to forestall muscle atrophy. The nature, extent, and rate of atrophic muscle changes will be thoroughly characterized. Alterations in muscle physiology, biochemistry, electromyography, and neuromuscular functions will be studied. The rate and completeness of recovery from atrophy will also be investigated. Basic mechanisms underlying muscle atrophy will be investigated in terms of biochemical factors regulating protein biosynthesis (initiation factors, prostaglandins, growth factors) and protein degradation. Methods for monitoring muscle atrophy by nuclear magnetic resonance spectral and image analysis will be evaluated. Specific exercise protocols, pharmacological agents, and electrical stimulation will be evaluated as countermeasures against atrophy.

W87-70260 **199-22-44**
Jet Propulsion Laboratory, Pasadena, Calif.
MUSCLE PHYSIOLOGY
R. H. Selzer 818-354-5754
(199-21-14)

This task seeks to carry out research and development of magnetic resonance (MR) techniques that can be applied to areas connected with the NASA Life Sciences program. The task has two components: an instrumentation component involving implementation of a magnetic resonance imaging device at JPL that will serve as a test bed for the future design of a flight MR system and a clinical application component for development of computer methods to measure muscle mass from magnetic resonance images (MRI) obtained with existing clinical MRI systems. The instrumentation component is described by Task 01 and the clinical applications by Task 02. Task 01 will involve development of new and better nuclear magnetic resonance (NMR) experimental procedures, achievement of better understanding of relation of basic NMR parameters to life processes, and development of NMR instrumentation that could be flown on a dedicated Life Sciences mission or early space station mission. In the first year of this Task 01, a state-of-the-art commercial NMR spectrometer will be procured. Work directed toward development of a zero-g NMR system, improvement of NMR procedures, and formulation of life-sciences related experiments and protocols will be carried out. Task 02, the development and validation of a method to measure muscle volume involve implementation of computer software to compute volumes from multiple cross-sectional MR images, determination of the accuracy and precision of the measurement and testing in animal models. The technique will be applicable to problems of evaluating muscle atrophy countermeasures and to the problem of pre- and post-flight monitoring of muscle atrophy of space station passengers. Complementary efforts to this program are underway at ARC and at UCLA. ARC will obtain MR images of bedrest subjects and send the images to JPL for analysis, UCLA will develop an experimental model with rats for testing the method.

W87-70261 **199-22-62**
Ames Research Center, Moffett Field, Calif.
CREW PRODUCTIVITY
H. Clayton Foushee 415-694-6114
(506-57-21; 505-35-21)

The objectives of this program are: (1) to develop better methodological approaches to the study of group process variables in naturalistic environments; (2) to achieve, through the use of these approaches, a better understanding of those factors which affect group function in aerospace environments; (3) to identify and assist in the solution of current and future operationally significant group performance problems in aerospace environments; (4) to provide guidelines for better crew reliability based upon aspects of selection, organization, and training; and (5) to track the impact of these approaches so that further improvement and understanding may be obtained. These general objectives are aimed at the production of practical guidelines for issues confronting

the U.S. space program. Heretofore, group productivity research has been of little use because it has typically been conducted in sterile laboratory research environments that are not generalized to aerospace operations. Moreover, the methods of analysis and performance criteria have had little to do with the conduct of meaningful work in challenging and more often stressful environments. One of the strengths of the proposed research plan is that it is organized to integrate the best available theoretical and empirical laboratory work and to test these principles in the most high fidelity environments available. It is believed that the net effect will be knowledge that can be immediately utilized by space operations planners.

W87-70262 **199-22-71**
Lyndon B. Johnson Space Center, Houston, Tex.
RADIOBIOLOGY
D. S. Nachtwey 713-483-5281

This RTOP describes a long-term program of research to examine the nature of the space ionizing radiation environment and determine its consequences for manned space operations. While currently available information is sufficient for early low inclination Shuttle missions, research priorities of the attached program are based on the assumption that long-term plans involve polar orbits, a permanently manned space station, manned sorties to geostationary orbit, lunar bases, and manned Mars missions. Based on knowledge obtained from previous research under this RTOP, exposure to ionizing radiation may be the limiting factor in both mission and career durations for space workers. Shielding considerations, based upon radiobiological responses, may influence significantly the detailed design and total mass of a spacecraft, especially for protection from solar particle events. To provide timely solutions to these problems in the mission planning stage, the underlying research must be conducted now. A plan is presented for research in specific areas of radiobiology and radiation dosimetry. Specific attention is given to the effects of high energy heavy ions of space since the problem is unique to NASA. A coordination effort with other NASA programs and programs of related government agencies will augment the information required by NASA in its long-term radiation research effort.

W87-70263 **199-22-76**
Langley Research Center, Hampton, Va.
SPACE RADIATION EFFECTS AND PROTECTION
R. R. Nunamaker 804-865-2893

In support of existing and future manned space efforts, including space station, manned GEO sorties, lunar bases, and interplanetary travel, there is a critical need to provide adequate space radiation protection measures with minimum weight penalties. As a result, comprehensive studies of the physical interactions and transport of space radiations (protons, electrons, and galactic heavy ions) with extended matter have been initiated. Because laboratory radiobiological studies suggest that high-energy heavy-ions (HZE particles) possess unique radiation damage characteristics, and may be highly carcinogenic for chronic low exposures, such as encountered in prolonged manned space missions, present research efforts are focused upon this particular component of the space radiation spectrum. Experimentally verified models of HZE particle interaction (especially nuclear fragmentation) and transport, necessary to determine ultimate shield requirements, are being developed in a collaborative effort involving theoreticians at Langley Research Center and experimentalists at Lawrence Berkeley Laboratory. Present research is focused upon accurately characterizing the radiation field inside the thick target absorber as to particle fluence, type, charge, mass, energy or velocity, and directions of travel. These models will be used to design advanced spacecraft and astronaut personal shielding and will enable more accurate assessments of astronaut radiation exposures and body self-shielding factors to be made. The overall objective is to develop a Space Radiation Protection handbook of evaluated methods for future use in manned spaceflight.

W87-70264 **199-22-92**
Ames Research Center, Moffett Field, Calif.
VESTIBULAR RESEARCH FACILITY (VRF)
D. L. Tomko 415-694-5723
(199-22-22; 199-40-12)

The Vestibular Research Facility (VRF) provides unique research opportunities to scientists whose work requires delivery of precisely controlled, vibration-free rotational and linear acceleration stimuli alone, or during exposure to altered-g background stimulation. In the broadcast sense, objectives of VRF's scientific research program are to: (1) conduct research on effects of precise rotational and linear accelerations on physiological mechanisms (e.g., vestibular system), during adaptation to altered background g levels provided by centrifugation; (2) define critical questions about vestibular function which require micro-gravity studies, and define methods to answer those questions; (3) facilitate planning of Neuroscience flight studies, provide required ground-based pilot studies, and enable pre- and post-flight testing; and (4) collect baseline data for the flight experiments on motion sickness, and on vestibular or other nervous system functions affected by micro-g. The second facet of the VRF program is involved with hardware development. The objectives of this part of the program are to: (1) provide completed VRF hardware to support the science objectives; (2) complete VRF hardware which is under development; and (3) design and implement experiment specific hardware. Science objectives will be thus achieved by providing a unique facility which will serve as a focal point for involvement of university-affiliated scientists, in-house scientists and engineers in performing experiments designed to support NASA's life science goals.

W87-70265 **199-30-32**
Ames Research Center, Moffett Field, Calif.
BIOSPHERIC MONITORING AND DISEASE PREDICTION
James G. Lawless 415-694-5900

The objective is to employ NASA-derived technologies to study and model the environmental parameters which influence the distribution and prevalence of vector-borne diseases. A series of NASA-sponsored workshops has identified malaria as the candidate disease. In situ studies will relate the environmental variables to the disease vector. These environmental variables will be studied by remotely sensed data. The relationship between remotely sensed data and vector population dynamics will be established and modeled. Modeling will be in the context of a Geographic Information System and used for purposes of predicting the temporal and spatial occurrence of vector populations and malarial transmission.

W87-70266 **199-30-62**
Ames Research Center, Moffett Field, Calif.
TROPICAL ECOSYSTEM RESEARCH
P. A. Matson 415-694-6884
(199-30-72)

Our objective is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the system. We will measure emissions of nitrous oxide, non-methane hydrocarbons and other gases in a range of sites representing major soil types, landscape positions (floodplains vs. upland) and disturbance types (natural vs. anthropogenic). In FY87, this research will be a continuation of the Amazon Ground Emissions (AGE) Project. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas fluxes from soil and vegetation and estimation of their importance over large areas.

W87-70267 **199-30-72**
Ames Research Center, Moffett Field, Calif.
BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
D. L. Peterson 415-694-5899
(677-21-35; 677-21-31)

The objectives are to characterize the pathways and measure

the rates of biogeochemical cycling of carbon, nitrogen, phosphorus, and sulfur in temperate ecosystems; to model these processes; to identify and map through remote sensing key indices diagnostic of changes in element flux; and to examine consequences of various disturbance regimes on atmosphere-water-biosphere interaction. The approach is to develop a scientific logic and framework for organizing ecosystems on gradients, such as open to closed (high to low nutrient turnover); identify and test key indices of ecosystem state on intact, artificially perturbed (fertilization, irrigation, etc.), and chronic (pollution) to abrupt (fire, harvesting, conversion) disturbance regimes which are predictive of element flux changes; and develop a regional data base reflecting these principles and conduct trace gas and hydrologic nutrient movement studies and models at appropriate geographic scales.

W87-70268 **199-30-99**
Goddard Space Flight Center, Greenbelt, Md.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-344-7122
(677-21-32)

The objective is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30m, 80m, 1km, 4km and 15km for selected local areas (30 and 80m), regional test sites (1km), continental test areas (4 and 8km), and the entire planet (15km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity and other large-scale vegetation information of interest to global science questions such as the Earth's radiation budget, biogeochemical cycles and the hydrological cycle. The expected results include: (1) the understanding of large-scale vegetation response and its relationship to atmospheric CO2 concentrations; (2) estimates of grassland biomass production across the entire continental ecological zones; (3) improved documentation of forest spatial extent for selected tropical and boreal forests; and (4) comparisons between disease outbreaks of Rift Valley fever and vegetation dynamics from East Africa for the time period of 1980 to 1985.

W87-70269 **199-40-12**
Ames Research Center, Moffett Field, Calif.
GRAVITY-SENSING SYSTEMS
M. L. Corcoran 415-694-5574
(199-40-22; 199-40-32)

All life on Earth has existed under the influence of gravity. In the animal kingdom a number of different systems have evolved to sense gravity. The degree to which Earth's gravity influences the development and normal functioning of these systems is not known. For the first time it is possible for organisms to live for prolonged periods of time without the influence of gravity. Thus, spaceflight provides the unique opportunity for significantly advancing our understanding of gravity-sensing systems. The objectives of this RTOP are to determine: (1) how animals sense gravity, (2) how they process and use information about gravity, (3) how both short- and long-term exposures to microgravity may affect the development, structure, physiology, and functioning of animal gravity-sensing systems, and (4) how gravity has influenced the evolution of g-sensing systems. To accomplish the above objectives, an integrated program of ground-based and spaceflight experimentation is required. The structure, chemistry, function, development, and evolution of representative graviceptors will be studied in the 1-g environment to provide a normative database. The effects of exposure to altered-g on the structure, chemistry and function of graviceptors in the adult organism, in the developing organism, and in multiple generations of organisms can then be assessed.

W87-70270 **199-40-22**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENTAL BIOLOGY
K. A. Souza 415-694-5251
(199-40-12; 199-40-32; 199-40-27)

Gravity has been an omnipresent force throughout the evolution of life on this planet. How it has influenced the evolutionary process and continues to impact the daily existence of life on this planet is largely unknown. The major objective of this research program is to further our understanding of the role and influence of gravity and the lack thereof, on the processes of reproduction, growth, development and aging. Specific hypotheses currently under investigation include: (1) gravity as a determinant of pattern specification in amphibian and avian embryogenesis; (2) gravity as required for the normal development of the musculoskeletal, nervous, and other organ systems in mammals, amphibia, and echinoderms; (3) cytoskeletal formation as influenced by the gravity vector in a variety of vertebrate and invertebrate species; and (4) gravity as it plays an important role in the behavior and aging of poikilotherms. Ground-based studies using hyper-gravity (centrifuges) and gravity vector randomization (clinostats) are performed to develop techniques and baseline data in support of flight experiments. Spaceflight investigations are conducted aboard the STS/Spacelab, Soviet Cosmos Biosatellites, and ultimately the Space Station.

W87-70271 **199-40-32**
Ames Research Center, Moffett Field, Calif.
BIOLOGICAL ADAPTATION
E. M. Holton 415-694-5471
(199-40-12; 199-40-22)

All biological species on Earth have evolved under the influence of gravity. In response to this force, organisms have developed structures to withstand gravity loads, as well as regulatory systems which may be optimized for the terrestrial gravity level (i.e., 1 G). The objectives of this RTOP are: (1) to compare and contrast support structures that living systems have evolved in response to gravity and to understand both structural function and regulation; (2) to determine whether gravity directly affects the cells regulating structural mass or exerts its effect extracellularly and to elucidate the mechanism(s) involved; (3) to determine whether temperature regulation is gravity dependent and if the mechanisms controlling temperature regulation are calibrated for 1 G; (4) to determine if normal terrestrial gravity plays a role in establishing basal metabolic rate and biorhythms; and (5) to use the microgravity of spaceflight to understand how organisms have adapted to gravity during evolution. To accomplish the above objectives, an integrated program of ground-based and spaceflight experimentation is required. A wide range of vertebrate and invertebrate species must be utilized to examine commonality of biological systems and the processes that organisms have evolved to cope with gravity.

W87-70272 **199-52-12**
Ames Research Center, Moffett Field, Calif.
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-694-5909
(199-52-22; 199-52-32; 199-52-42)

The overall concept of the program is to understand the history of biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and the early solar system. The program has three basic goals: (1) Trace the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determine the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system in order to develop theories about the formation of the solar system and the prebiotic evolution and origin of life; and (3) determine the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies. A series of workshops has explored major scientific questions, to determine which are amenable to theoretical, experimental, observational or analytical

approaches and to recommend the major research areas of the program that are necessary to pursue defined goals and objectives. These recommended research thrusts are: (1) nucleosynthesis of biogenic elements with ejection into the interstellar medium; (2) chemical evolution in the interstellar medium; (3) protostellar collapse; (4) chemical evolution in the solar system; (5) growth of planetesimals from dust; and (6) accumulation and thermal processing of planetoids.

W87-70273 **199-52-22**
Ames Research Center, Moffett Field, Calif.
PREBIOTIC EVOLUTION
S. Chang 415-694-5733
(199-52-12; 199-52-32; 199-52-42)

The objective of research in prebiotic evolution is to understand the impact of the development of Earth and other planets on the evolutionary sequence leading from simple chemicals to living systems. The approaches taken to meet the objective fall into two major study areas, each of which involves the use of both laboratory experiments and computer simulations: (1) the consequences of planetary evolution on the physical environments of the Earth and planets; and (2) the evolution of molecules and molecular systems under the constraints imposed by the physical environment, and by the appearance, a posteriori, of living systems on Earth. Studies of Planetary Evolution assess the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces, on both global and microenvironmental scales, which could have been involved in, or provided constraints on the development of living systems for Earth and other planets. Studies of Molecular Evolution focus on the energetics, dynamics and synthesis of chemicals and chemical systems in order to elucidate feasible mechanisms by which these systems acquired biological attributes within the constraints of the environment.

W87-70274 **199-52-26**
Langley Research Center, Hampton, Va.
EARLY ATMOSPHERE: GEOCHEMISTRY AND PHOTOCHEMISTRY
Joel S. Levine 804-865-2187

The objectives are to develop a better understanding of the geochemical and photochemical processes that controlled the composition of the atmosphere over geological time. The approach consists of: (1) the development of a geochemical flux model to investigate the transfer of carbon, nitrogen oxygen, sulfur, and chlorine species between the atmosphere, oceans, solid Earth, and biosphere over geological time; (2) photochemical calculations of the composition of the early atmosphere and its evolution over geological time; and (3) laboratory lightning experiments in various paleoatmospheric gases mixtures in the Langley Lightning Facility.

W87-70275 **199-52-31**
Lyndon B. Johnson Space Center, Houston, Tex.
CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES
Everett K. Gibson, Jr. 713-483-6224

The goal of this study is to investigate the elemental and molecular compositions of volatiles present in interplanetary dust particles (IDP's). Interplanetary dust is important to studies of the origin of the solar system because it is the material from comets and asteroids -- the smallest surviving bodies from the early solar system. The investigation will obtain compositional information about the volatiles present at the time of formation of these primitive particles. Because of the possibility that the dust particles may have a cometary origin, their analysis could provide information about the volatiles associated with the dusty component present in comets. Exobiological interest in cosmic or interplanetary dust particles stems from their potential for contributing to the elucidation of the cosmic history of the organogenic elements (i.e., H, C, N, O, S, and P) that make up all living systems. Therefore, the study of IDP's will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

W87-70276 **199-52-32**
Ames Research Center, Moffett Field, Calif.
THE EARLY EVOLUTION OF LIFE
L. I. Hochstein 415-694-5938
(199-52-22; 199-52-42)

This research explores the mechanisms, processes and environments associated with the early evolution of life on Earth as an approach for understanding life elsewhere in the universe. Two repositories of evolutionary information are examined; namely, the molecular record in living microorganisms and the geologic record in rocks. Biological studies address the early evolution of the complex systems that constitute the essential attributes of life. Energy transduction is being studied by examining archaebacteria (e.g., extreme halophiles, thermophilic acidophiles) and comparing their properties with those of eubacteria. The development of oxygen-requiring pathways in lipid synthesis is investigated both in eubacteria and in eukaryotes. Geologic studies seek to elucidate earlier biochemistries through analyses of ancient biological material preserved in stromatolitic rocks. The paleoenvironment (e.g., its structural setting and the chemical composition of its ocean and atmosphere) is also being described. The goal is to understand the nature and evolution of primitive microorganisms, especially in the context of those forces which guided the evolution of the planet itself.

W87-70277 **199-52-42**
Ames Research Center, Moffett Field, Calif.
EVOLUTION OF ADVANCED LIFE
D. Des Marais 415-694-6110
(199-52-22; 199-52-32; 199-52-62)

The goals of this research are to understand possible evolutionary pathways for advanced life; to examine the influence of astrophysical, stellar and solar system events on the evolution of advanced life on Earth; to investigate ancient atmospheres; and to develop a program plan for a paleontological data base. This RTOP represents an expansion of research previously incorporated in the old Life in the Universe RTOP. It has now been separated out into a new RTOP dealing with studies of the evolution of advanced life on Earth, set against the background of the story of cosmic evolution, and dealing specifically with the effects of events in space on biological evolution. It also asks for the first time important questions about general laws which may govern the emergence of advanced life in the context of planetary environments which might exist elsewhere in the universe.

W87-70278 **199-52-52**
Ames Research Center, Moffett Field, Calif.
SOLAR SYSTEM EXPLORATION
G. C. Carle 415-694-5765
(199-52-22; 199-52-32; 199-80-82)

The objective of the work is to provide specific information on the elemental and chemical composition, mainly in respect to gases and volatiles, of the atmospheres and surfaces of solar system bodies including planets and their satellites, comets, asteroids, meteorites, and dust in space. This information is essential for selecting or devising the most appropriate model for the evolution of the solar system and for each of the investigated bodies. Further, it will provide a basis for understanding the conditions necessary for the origin of life by comparisons of the evolution and chemistries of these bodies. Improved methods, instrumentation, and experiments will be developed for in situ chemical analyses of the volatile species associated with the bodies to be investigated. Special emphasis is directed to development of the gas chromatographic approach since it is now proven to be among the most effective means for measuring complex, gaseous mixtures. Improvements in gas chromatographic techniques, e.g., multiplex chromatography, and components, e.g., detectors and columns, will be rigorously explored. Other techniques will be investigated and developed as appropriate.

W87-70279 **199-52-62**
Ames Research Center, Moffett Field, Calif.
THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)
B. M. Oliver 415-694-5166

The Search for Extraterrestrial Intelligence (SETI) program is an effort which has the following five objectives: (1) to conduct an extensive five-year effort to determine the most cost effective way to do SETI and to carry out limited but significant SETI observations, (2) to design, build, and test a SETI prototype system, (3) to field test the prototype at Goldstone and Arecibo for initial SETI observations, (4) to evaluate the SETI system for its value for radio astronomy, and (5) to explore new technologies for SETI. In accomplishing these objectives, telescope-SETI hardware interfaces will be determined, alternative observational techniques investigated, and various signal processing and identification methods examined in software and optimized for implementation in hardware. The signal processing system will permit signals of natural and artificial origin to be sought over the entire sky between 1 and 10 GHz up to a maximum sensitivity of 10 to -23 watts per square meter, and selected solar-type stars will be searched in the 1 to 3 GHz range up to a maximum sensitivity of 10 to -27 watts per square meter. The plan is divided into five hardware phases, each of which improves the prototype capability.

W87-70280 **199-61-11**
Lyndon B. Johnson Space Center, Houston, Tex.
LUNAR BASE CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM
D. L. Henninger 713-483-2781

Advanced solar system exploration scenarios mandate wise utilization of non-terrestrial resources and efficient regeneration of life support consumables to reduce costly, energy intensive resupply launches from Earth. The concept of a Controlled Ecological Life Support System (CELSS) to sustain human endeavors in space and on other planets is central to such scenarios. Lunar Base is one of NASA's advanced mission scenarios in which CELSS plays an integral role. While the general concepts of a Lunar Base CELSS and Environmental Control and Life Support System (ECLSS) for space station are similar, the availability of Lunar resources and anticipated activities at Lunar Base add new pieces to the CELSS puzzle. The objective is to continue and initiate new research in support of a Lunar Base CELSS. A series of tasks will investigate the uses of Lunar resources within a Lunar Base CELSS, providing the framework for a self-sufficient Lunar agricultural station as part of a manned Lunar Base. The FY-87 approach is to: (1) initiate laboratory research on the use of Lunar regolith as a terrestrial-like soil to grow higher plants, (2) investigate the formation and utility of various species of special property minerals (zeolites) synthesized from Lunar regolith, (3) convene a workshop to identify and prioritize Lunar Base CELSS research topics, and (4) evaluate material, mass flow, system buffering and energy requirements of a Lunar Base CELSS.

W87-70281 **199-61-12**
Ames Research Center, Moffett Field, Calif.
BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)
R. D. MacElroy 415-694-5573
(199-61-23)

This RTOP supports the scientific experiments and technological investigations, and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of higher plants, algae, microorganisms and physical-chemical devices for the production of water, food and oxygen, and absorption of carbon dioxide and waste materials in orbit or on planetary surfaces. The goal is to insure recycling and regeneration of materials needed for crew support. Included also are studies of the control and the efficiency of such bioregenerative systems. These investigations are concerned with the rates at which organisms or physical-chemical devices produce or consume biomass, food, oxygen, carbon dioxide, potable water, and fixed nitrogen in response to changes in environmental variables such as temperature, atmospheric gas composition, light intensity, duration and quality, humidity, wind speed, and the composition of nutrient medium. These investigations are also conducted to improve the methods available for increasing system efficiency, stability and control through automated sensing, data collection, and data interpretation. Data collected forms a science-requirements base for the design and operation of the Controlled Ecological Life Support System (CELSS) Breadboard Project.

W87-70282 **199-61-41**
Lyndon B. Johnson Space Center, Houston, Tex.
MAN-MACHINE ENGINEERING REQUIREMENTS FOR DATA AND FUNCTIONAL INTERFACES
Jeri W. Brown 713-483-2368

The objectives of this report are: to move toward quantification of man-machine engineering data, both on the ground and in flight; to continue to pursue state-of-the-art technology and to advance that technology for the purpose of creating more effective and efficient man-machine interfaces for manned spacecraft; and to improve techniques of man-machine engineering design so that innovative steps may be taken toward creating better crew interfaces in future vehicles. The approach taken is: to implement a series of continuing tasks to identify and implement workable instrumentation packages for acquiring quantitative man-machine engineering data in one-g, simulated zero-g, and actual zero-g; to continue those efforts currently defined that lead toward definitive design requirements for use as inputs to the Automated Crew Station Design System; and to pursue feasibility studies of promising new crew interface items.

W87-70283 **199-70-12**
Ames Research Center, Moffett Field, Calif.
EXTENDED DATA BASE ANALYSIS
Christopher L. Schatte 415-694-6748

The objective of this effort is to further analyze spaceflight data beyond that contemplated by the investigators participating in the original mission plans. Investigators will be given the opportunity to further examine the results of their flight experiments, expand on their previous analyses or develop new approaches to enhance the scientific yield of flight data. This data includes analog and digital information recorded during flight and biological samples which have been subjected to microgravity. This RTOP also supports the publication and presentation of significant results.

W87-70284 **199-70-22**
Ames Research Center, Moffett Field, Calif.
DATA ANALYSIS - EXOBIOLOGY IN SOLAR SYSTEM EXPLORATION
G. C. Carle 415-694-5765
(199-52-52; 199-52-12; 199-52-22)

The objective is to provide a detailed understanding of the chemical, elemental, and structural composition of the bodies of the solar system, including the planets and their satellites, comets, asteroids, meteorites, and dust. Knowledge of these bodies is critical to the development of new and the refinement of existing models of the evolution of the solar system and its relationship to prebiotic evolution, and the origin and early evolution of life. Further, such knowledge will allow a better understanding of what the prebiotic conditions were on Earth and why apparently only one planet - Earth - has evolved life. Within the core mission plan of the Solar System Exploration Committee, a number of opportunities for exploring various bodies of the solar system have been identified. Without exception, there will be a need to acquire information important to exobiological interests during each of these missions. By developing interdisciplinary laboratory data bases (inclusive of Exobiology) which are specific to these missions, exobiological interests can be effectively represented during mission planning, development, and execution thus insuring participation even though no flight instrument representing the community has been included.

W87-70285 **199-70-33**
Goddard Space Flight Center, Greenbelt, Md.
MEDICAL INFORMATION MANAGEMENT SYSTEM (MIMS) (COMPUTER AIDED DIAGNOSTIC WITH MATHEMATICAL MODEL)
Sidney Alterescu 301-344-8106

The long term goals of this RTOP are: to develop a flexible format data base system which can be utilized to support flight studies to be gathered on shuttle space labs. Under this RTOP software previously developed for mainframe and mini-computers will be rewritten for micro-computers.

W87-70286 **199-80-32**
Ames Research Center, Moffett Field, Calif.
VESTIBULAR RESEARCH FACILITY (VRF)
R. W. Mah 415-694-6538
(199-22-92)

The objective is to develop a Vestibular Research Facility (VRF) Scientific Research Program which will permit scientists to conduct fundamental vestibular research using state-of-the-art research capabilities. The research capabilities will also provide a wider range of experiment stimuli than is available elsewhere. Current theories in vestibular research are that the vestibular system is intimately involved with Space Adaptation Syndrome, as it is with terrestrial motion sickness. It is believed that a fundamental understanding of the vestibular system is necessary before a satisfactory prevention or cure can be derived. For this reason NASA is developing, and will make available to the science community, a state-of-the-art VRF laboratory which will provide a wide range of precision controlled experimental stimuli whose performance characteristics are unsurpassed. The development of the ground version of the VRF module is proceeding under the guidance of the VRF Science Advisory Committee. The hardware, instrumentation and support equipment are housed in a specially constructed vestibular research laboratory. The ground version of VRF includes many, but not all, of the stimulus and recording modes of the flight version. The milestone schedule is to have the VRF science laboratory available for the scientific community to use in FY86 as described in the VRF Project Plan dated June 1984. This RTOP is transferred to 199-22-92.

W87-70287 **199-80-34**
Jet Propulsion Laboratory, Pasadena, Calif.
ULTRASOUND IMAGE ENHANCEMENT
J. A. Rooney 818-354-3942
(199-10-24)

The basic objective of this research is to apply digital image processing techniques to ultrasound images obtained in collaboration with the French. Use of image processing techniques developed at JPL may permit quantification and improved display of these medical ultrasound data. Such improvements will lead to the extraction of additional data of clinical interest from the videotapes. The specific objectives of this task include development of collaboration between Centre National d'Etudes Spatiales (CNES) and JPL, the examination of compatibility of existing JPL processing software with existing French 2-D ultrasound instrumentation, development of a system to process the ultrasound data from the French and finally, development of an integrated operational system. The approach to be used is divided into three phases. Phase 1 will include the development of hardware and software interfaces between the French hardware and the JPL image processing facility, the testing of methods for 2-D image enhancement and quantification, and the determination of specifications for a system to process flight data. It will include development of image processing methodologies for feature extraction and quantification. Phase 2 will involve the extension of the image processing to 3-D. Phase 3 will include transfer of the software and hardware requirements. In addition, consideration will be given to advanced processing for potential future work. This effort will permit us to continue to work with the French ultrasound team, collaborate with them in areas where they have identified a need and to provide a capability that will strengthen both the international and U.S. Space programs.

W87-70288 **199-80-82**
Ames Research Center, Moffett Field, Calif.
ADVANCED TECHNOLOGY DEVELOPMENT - FUTURE LIFE SCIENCES FLIGHT EXPERIMENTS
G. C. Carle 415-694-5765
(199-52-52)

Studies will be conducted to provide fully developed advanced flight instrumentation concepts and laboratory breadboards for future life sciences flight experiments where accurate, comprehensive, and sensitive instruments and highly specialized devices will be required. These instruments, experiment concepts, and devices are critical to the science needs of the life Sciences community to gain specific data only obtainable from space flight and unaddressed elsewhere, e.g., exobiology for measurements of the biogenic elements and their compounds in solar system exploration, life support for monitoring of the cabin environments of space station, and space biology for advanced space station centrifuge. Instrument and experiment development based on advanced analytical concepts and engineering technology will be conducted. Feasibility studies will be performed and, based on validated concepts, prototypes will be constructed and tested. Experiments and instruments based on these development efforts will be proposed for flight.

W87-70289 **199-80-92**
Ames Research Center, Moffett Field, Calif.
ATD NEAR TERM FLIGHT HARDWARE DEFINITION
G. H. Bowman 415-694-6273

The objective of this RTOP is to support the preliminary design, early development and testing of hardware required for projected flight experiments. New hardware will be identified through the analysis of scientific objectives and requirements described in the responses to the Announcement of Opportunity (AO), and through previous flight experiences. The newly identified hardware will undergo further detailed requirements definition, an assessment of available state-of-the-art components, a conceptual design, and finally, breadboarding and testing. After the prototype has been developed the Life Sciences Flight Experiments Program will assume the responsibility for developing the flight hardware.

W87-70290 **199-90-62**
Ames Research Center, Moffett Field, Calif.
SPACE STATION LIFE SCIENCES
R. D. Arno 415-694-6640

The objective of this RTOP is to integrate Life Science activities in space station research, in order to be certain that the Space Station Research Facility will accommodate a wide range of high priority experiments. The areas of particular interest include biochemical research, gravitational biology, animal research, exobiology and biospheric research. Numerous scientific and engineering studies are being conducted to identify representative scientific experiments which would be appropriate for the space station. The equipment and facilities to conduct these experiments will then be evaluated. These representative experiments would then be grouped into various payload scenarios for planning purposes, to determine the space, crew time, power, stowage, waste materials, and other factors important in outfitting a Life Science Laboratory Module. In addition, the results of the science and engineering definition studies will serve as a basis for the future development of the flight hardware for space station. This RTOP was transferred from 199-80-02 in FY86, and is transferred to UPN 805 in FY87.

W87-70291 **199-90-68**
Lewis Research Center, Cleveland, Ohio.
LIFE SCIENCES EDUCATION
R. Lynn Bondurant, Jr. 216-433-5583

The objective of this RTOP is to add 6 titles to a 13 part NASA educational TV series which is intended to summarize NASA Life Sciences Research to date in order to disseminate new NASA information about Life Sciences to schools nationwide via satellite and public television. In addition, the programs would distribute other Life Sciences knowledge to the schools in support of the

President's goal to enhance science and engineering education in the nation's schools. (The Space Act of 1958 also requires NASA to distribute its findings on a wide basis.) The approach is to bring Life Sciences experts to Lewis to videotape interviews with them.

W87-70292 **199-90-71**
Lyndon B. Johnson Space Center, Houston, Tex.
INTERDISCIPLINARY RESEARCH
Joseph P. Kerwin 713-483-3503

The Life Sciences Directorate at Johnson Space Center is responsible for the development of a comprehensive biomedical research program in support of manned space flight. This broad, multidiscipline mandate to acquire new knowledge is directed toward the acquisition of definitive data regarding the effects of the space environment on life systems in order to define the critical physiological and psychological variable which must be integrated into the overall considerations of spacecraft designers and mission planners. The objective of the interdisciplinary research RTOP is to provide flexibility in the accomplishment of this goal.

Solar Terrestrial SR&T

W87-70293 **442-20-01**
Goddard Space Flight Center, Greenbelt, Md.
ATMOSPHERE-IONOSPHERE-MAGNETOSPHERE INTERACTIONS
R. E. Hartle 301-344-8234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, to identify and understand the physical and chemical processes operating in these regimes, emphasizing how they interact. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the study of long-term phenomena, comparison of data with new theories and models, correlative studies of data obtained from various satellites and ground based observatories, and the deposition of additional data in the National Space Science Data Center. The essential data to be used in this investigation include electron densities and temperatures, ion and neutral composition, neutral winds, ion temperatures and drifts, electric fields, magnetic fields, electromagnetic radiation and energetic particles of magnetospheric and ionospheric origin. These data are used to determine the various interrelated chemical, compositional, dynamical and energetic states of the ionosphere, exosphere, thermosphere and mesosphere and the transport and deposition of mass, momentum and energy in and between these physical regions. These basic properties and processes are then used to analyze specific geophysical phenomena such as: atmospheric escape, electric field induced ion drifts in the ionosphere, chemistry and dynamics of mid and high latitude troughs, auroral substorms, ionospheric storms, Joule heating, PCA events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamic processes, equatorial bubble formation, SAR Arcs, etc.

W87-70294 **442-20-01**
Goddard Space Flight Center, Greenbelt, Md.
SPACE PLASMA DATA ANALYSIS
C. R. Chappell 205-544-7591

The objective of this RTOP is an adequate understanding of the dynamics of low-energy plasma in the Earth's magnetosphere. This research involves the analysis of data from spacecraft and ground-based laboratory investigations. This individual RTOP consists of a coordinated set of tasks which includes: (1) analysis of the Light Ion Mass Spectrometer data from the NASA/DOD SCATHA satellite, (2) laboratory simulation of plasma flow around different objects, (3) modeling of thermal plasma processes, (4) analysis of data and development of models relating to the effects of spacecraft plasma sheaths upon low-energy charged particle data, and (5) analysis and development of models relating to plasma wave processes in multispecies plasmas.

W87-70295 **442-20-02**
Goddard Space Flight Center, Greenbelt, Md.
DATA ANALYSIS - SPACE PLASMA PHYSICS
L. F. Burlaga 301-344-5956

The basic objective is to study the observed properties of the interplanetary medium and the magnetospheres of the Earth and other planets and to identify and understand the physical processes operating within and between these regimes. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the long-term phenomenological studies, comparisons of data with new theories and models, correlative studies of data obtained from various satellites and ground-based observatories, and the deposition of additional data in the National Space Sciences Data Center (NSSDC). The essential data to be used in this investigation include measurements of magnetic fields, plasmas, energetic particles, plasma waves and radio radiation. These data are used to determine the various dynamical and energetic states of the interplanetary medium and the magnetosphere and to assess the transport and deposition of matter and energy within and between these physical regions. These basic properties and processes are then used in the study of specific geophysical phenomena such as interplanetary sectors and flows, energetic particle acceleration, auroral current systems, and magnetic fields and plasma in the plasma sheet and the magnetotail. Basic theory complementary to the data analysis effort is carried out in the areas of kinetic plasma physics and the motion of charged particles in the electric and magnetic fields.

W87-70296 **442-20-04**
Goddard Space Flight Center, Greenbelt, Md.
ENERGETIC PARTICLES AND PLASMAS IN THE MAGNETOSPHERES OF JUPITER AND SATURN
T. G. Northrop

The overall objective of this study is to gain an understanding of the sources, sinks and dynamics of charged particles (electrons, ions, and charged dust grains) in the magnetospheres of Jupiter, Saturn, Earth, Uranus and pulsars. This work will apply plasma theory and the theory of charged particle motion to data taken by Pioneers 10 and 11, and by Voyagers 1 and 2. Included is a study of the effect of particle stability on the gross structures in Saturn's rings, structures which have not been explained by purely gravitational forces on the ring material by Saturn and its moons. We have prior to now been successful in pointing out the possible role of electromagnetic forces combined with gravitational forces in producing some major changes in optical depth with radius observed by the Voyagers. We will extend this work to derive a model for the equilibrium of charged dust grains in a ring system. Such a model is needed to complete the identification of the inner edge of Saturn's B ring with the inward stability limit of such grains in the ring plane. The stability calculation, being linear, is much simpler than the equilibrium, which is non-linear and probably involves solution of the Poisson equation in the presence of field-aligned currents through Saturn's ionosphere. An explanation of how an equilibrium (stable or unstable) might occur would make the identification much more convincing.

W87-70297 **442-36-55**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLES AND PARTICLE/FIELD INTERACTIONS
Keith W. Ogilvie 301-344-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in the interplanetary medium and magnetospheres of Earth and other planets. This requires continuous improvement of measurement techniques, concentrating on advanced concepts of plasma detectors, ion mass discrimination at high energies, magnetometers and radio and plasma wave analyzers. Work is also under way to improve the theoretical description of plasma properties, and to improve techniques for the interpretation of the results of space

plasma experiments, requiring corresponding improvements in numerical techniques and in methods of data display.

W87-70298 **442-36-55**
Marshall Space Flight Center, Huntsville, Ala.
SPACE PLASMA SRT
T. E. Moore 205-544-7633

The objectives of this and another closely related RTOP are to develop space plasma instrumentation for automated spacecraft, sounding rocket, and shuttle payloads. To accomplish these objectives, the following tasks will be performed: (1) further develop, by addition of a radio frequency mass analyzer, the Differential Ion Flux Probe (DIFP) instrument to be used for the measurement of multiple directed, low-energy ion streams. This techniques has been applied in laboratory wind tunnel studies, rocket flights into the aurora, and shuttle-based studies. Several future flight opportunities exist; (2) design and develop an advanced Low-Energy Ion Mass Spectrometer for the measurement of low-energy plasma distributions in the ionosphere and magnetosphere. Instruments have been flown on several sounding rockets. An angle scanning, differential energy analyzer with variable energy bandwidth will be developed for future applications; (3) continue development of a low-energy electron analyzer tailored to measurement of positive spacecraft floating potential. This concept has been successfully demonstrated in the laboratory and will be upgraded to flight-quality hardware.

W87-70299 **442-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
A. Barnes 415-694-5506

The overall objective is to investigate the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. Theoretical studies will be conducted, aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind-Venus interaction will be conducted.

W87-70300 **442-36-55**
Jet Propulsion Laboratory, Pasadena, Calif.
QUANTITATIVE MODELLING OF THE MAGNETOSPHERE/IONOSPHERE INTERACTION INCLUDING NEUTRAL WINDS
M. Harel 818-354-4205

A theoretical investigation of ionosphere-magnetosphere coupling is conducted to evaluate the effect of neutral ionospheric winds on plasma convection in the magnetosphere, and the driving of these neutral winds by magnetospheric plasmas during substorms. In the first phase of this investigation, which has been completed, passive and interactive self-consistent models for the terrestrial ionosphere and magnetosphere were developed. These models combine the time-dependent Rice Convection Model with a storm-time neutral wind model developed by Dr. J. Forbes of Boston University. The models were tested for quiet-time and substorm periods during the Controlled Data Analysis Workshop (CDAW) 6 and GISMOS events and yielded very realistic currents and electric fields at mid- and low-latitudes. The objective during this second phase of the study is to expand the storm simulation activity to include the CDAW 8 events. Simulation of the GISMOS event of January 18 to 19, 1984 will be continued, using newly-obtained convection patterns from National Center for Atmospheric Research (NCAR). The GISMOS simulations and interpretation are in collaboration with many other theoretical and experimental groups. The following steps are planned for FY-87: (1) define the polar cap boundary and potential distribution based on the NCAR study of the GISMOS event; (2) use these new boundary conditions and improved wind fields (from Roble) to run our model for the GISMOS storm. Results will be compared with satellite and ground base observations and be extensively interpreted; (3) participate in the future CDAW 8 workshop at Goddard Space Flight Center. Like previous CDAW workshops, fruitful collaboration between various groups of theorists and experimentalists should result from studying the same event; (4) improve and refine our self-consistent model based on experience from steps (1)-(3) above; (5) develop a comprehensive graphics package in support of the model and take first steps to make the model and graphics package available to other investigators.

W87-70301 **442-36-56**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE AND PARTICLE/PHOTON INTERACTIONS (ATMOSPHERIC MAGNETOSPHERIC COUPLING)
James P. Heppner 301-344-8797

The objective is to develop experimental and theoretical approaches for investigating the processes which provide strong coupling between the neutral atmosphere, the collision dominated ionospheric plasma, and the collisionless magnetospheric plasma. Within the framework of this overall objective, specific sub-objectives are identified in terms of having: (1) key significance, (2) goals which are attainable with limited resources, and (3) close ties to future projects and programs. Emphasis is placed on electric fields and the associated transport and energization of particles that occurs within the Earth's magnetic and gravitational fields. Related topics include: electric fields in the Earth-ionosphere cavity, the transformation of atmospheric ions to trapped radiation, auroral particle acceleration mechanisms, plasma instabilities producing ionospheric irregularities, etc. Improved instrumentation is being developed for low light level observations of tracer chemicals, measurements of low energy particles and electron temperature and density measurements. Properties of double probes in low density plasmas are being studied. Models for the injection, diffusion, and transport of tracer particles are being developed for planning and interpreting future chemical release experiments.

W87-70302 **442-36-57**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ACCELERATOR FACILITY: MAINTENANCE AND OPERATION OF A CALIBRATION FACILITY FOR MAGNETOSPHERIC AND SOLAR-TERRESTRIAL EXPERIMENTS
S. K. Brown 301-344-5795

The GSFC Parts Branch operates a nuclear particle calibration facility consisting of a 2 MeV Van de Graaff and a 250 keV electrostatic accelerator. The facility provides particle energies from 50 eV to MeV, and protons via reactions to approximately 20 MeV. Particle beams available range from electrons to Kr84, with fluxes from approximately 1 particle/cm2 sec to approximately 10 particle/cm2 sec. It has been a unique facility in the world in this low-energy region. Some of its abilities are now duplicated up to 350 keV by an accelerator at MPI Lindau. For several years, all work in this facility has been in support of magnetospheric and solar terrestrial programs. Although some X-ray work began this year, over the past five years, machine time has been split fairly evenly between calibration and testing of satellite experiments, testing and development of new particle detector systems, and sounding rocket payloads. Machine usage in the previous 12 months has held steady or increased slightly about 25% of full working weeks. The machines were operated at least once per week for more than 30 weeks during the last year, including maintenance, set up for incoming instruments, etc.

W87-70303 **442-36-58**
Goddard Space Flight Center, Greenbelt, Md.
THEORETICAL STUDIES AND CALCULATION OF ELECTRON-MOLECULE COLLISION PROCESSES RELEVANT TO SPACE PLASMA PHYSICS
A. Temkin 301-344-8091

The objective of this RTOP is to do calculations of electron-molecule scattering, primarily vibrational and rotational excitation of molecules of atmospheric (terrestrial and planetary) importance, and also astrophysical utility in the general category of space

(plasma) physics. The ultimate aim is to calculate collision cross section with N2, O2, and CO. Under present investigation e-N2 scattering is of obvious atmospheric interest. Specifically the vibrational excitation of N2 is important in understanding the mechanism causing stable auroral red (SAR) arcs. It is also important in understanding the secondary photoelectron flux and the electron heating rate in the ionosphere. N2 is also a chief constituent of the atmosphere of Titan and the excitation cross section is expected to be important in understanding its spectral features. We shall next consider the CO molecule. CO is the second most abundant molecule (after H2) in the galaxy. Since H2 is invisible and since CO tracks H2 and (via its J=1 O transition) is visible at intergalactic distances its excitation mechanisms are important in understanding aspects of the interstellar medium. Collisions with electrons are expected to be important on the interface between H2 and H II regions. Finally we shall calculate e-O2. It is clear even without discussion that O2 is vital to the understanding of many atmospheric terrestrial phenomena. O2 is also an important constituent (together with CO) of the atmosphere of Venus.

Sounding Rockets--Solar Terrestrial

W87-70304 **445-11-36**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS
James P. Heppner 301-344-8797

The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, and electric fields in the atmosphere, ionosphere, and near-Earth magnetosphere. Sounding rockets provide the only access for in situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Emphasis is also placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Historically, this approach has logically been extended to include: (1) piggyback experiments on orbiting vehicles, (2) experiments involving sounding rocket flights in association with simultaneous satellite measurements in selected geometrical coincidence between trajectories, (3) flight testing of new instrumentation and measurement techniques, (4) shuttle flights of low cost, rocket type payloads, and (5) investigations of the electrodynamics of middle atmosphere (i.e., below 90 km) using sounding rockets for deploying payloads which descend via parachutes.

Technical Consultation and Support Studies

W87-70305 **643-10-01**
Lewis Research Center, Cleveland, Ohio.
SPECTRUM AND ORBIT UTILIZATION STUDIES
J. W. Bagwell 216-433-3502

The objectives of this RTOP are to: provide technical consultation services support in the area of space communication services with particular emphasis on preparing for international meetings relating to the fixed-satellite service (FSS), the broadcast-satellite service (BSS), and the mobile-satellite service (MSS); provide the technical basis and regulatory support needed to obtain sufficient orbit/spectrum to meet current and projected requirements of NASA and the United States; and perform studies, develop analytical methods for spectrum management, conduct evaluations, identify technology status and needs, perform critical technology developments, perform measurements (where necessary) to determine sharing criteria, and evaluate alternatives that result in efficient and cost-effective use of the geostationary orbit/spectrum resource. Specifically, these activities will: (1) Support domestic and international preparations for the 1988 Space Services WARC with primary emphasis on the FSS, and secondary emphasis on the BSS and the MSS. (2) Support domestic and international MSS planning. (3) Conduct the described activities within the framework and schedules of the applicable CCIR Study Groups, the special preparatory committees established in the United States, and the national and international meetings called to support preparations for the Conferences. Efforts planned are a combination of in-house and contract activities.

W87-70306 **643-10-01**
Jet Propulsion Laboratory, Pasadena, Calif.
SPECTRUM AND ORBIT UTILIZATION STUDIES
A. Vaisnys 818-354-6219
(643-10-05)

The objective of this RTOP is to insure the growth of space applications by providing the technical basis to obtain sufficient orbital positions to meet current and projected requirements. The result of this work will be used by NASA and other government agencies for the purpose of supporting CCIR and the 1988 World Administrative Radio Conference; in making decisions on frequency and orbit utilization and assignments, Earth-station and satellite approvals; and in providing for the growth of existing and new multi-purpose satellite services. The specific objective for FY87 is to support NASA Headquarters with the analysis of achievable satellite antenna performance characteristics; specifically to determine a practical specification for sidelobe characteristics. The approach is to survey the available techniques for sidelobe reduction, provide analytical studies on their effectiveness, interact with antenna manufacturers on cost/performance tradeoffs, and define a practical sidelobe specification which would be proposed as the new CCIR standard.

W87-70307 **643-10-03**
Jet Propulsion Laboratory, Pasadena, Calif.
PROPAGATION STUDIES AND MEASUREMENTS
E. K. Smith 818-577-6820
(643-10-01; 650-60-15; 643-10-05)

Radio wave propagation effects in the Earth-space environment must be understood and accounted for in the design and specification of space communications systems. The Propagation Studies and Measurements program provides the focal point for national activities which support NASA's applications programs, development of prediction models, frequency allocation recommendations, orbit and spectrum use decisions, system specification and performance criteria related to space communication. The objectives of the NASA Propagation Studies and Measurements Program are to provide an understanding and analysis of the basic propagation mechanisms which hinder reliable Earth-space communications, and to develop predictive models for the quantitative evaluation of propagation effects in the bands allocated for space applications. The objectives of the program are accomplished through participation in the Mobile Satellite Experiment (MSAT-X, 1400 to 1600 MHz), the Advanced Communications Technology Satellite (ACTS, 30 to 20 GHz), the work of the International Radio Consultative Committee (CCIR), in propagation and the preparation for World or Regional Administrative Radio Conferences (WARCs or RARCs), and in the preparation of overview material. The work of the program consists of three types of activities: (1) Propagation measurements and experiments, (2) Analysis and modeling of propagation effects, and (3) Propagation assessment and evaluation. The first activity involves flight experiments or simulated flight experiments; the second is concerned not only with the analysis and publication of results from the first, but also with theoretical studies and use of other data bases; while the third is characterized by CCIR contributions, and the propagation handbooks for slant paths.

W87-70308 **643-10-05**
Jet Propulsion Laboratory, Pasadena, Calif.
ADVANCED STUDIES
A. Vaisnys 818-354-6219
(650-60-15; 643-10-01; 643-10-03)

The objectives of this RTOP are to provide studies of system concepts leading to the growth of advanced communications satellite system services, other than provided by MSAT projects, and to ensure the compatibility of NASA's communications flight programs with other space and terrestrial services. The technical objectives of this RTOP for FY87 are to continue system concept design and analyses on: (1) integrated aeronautical, maritime and land mobile satellite system, and (2) satellite based data collection and interactive data networks, and (3) intersatellite links. The division of effort among these areas will depend on: (1) results of the studies underway in FY86, and (2) agreement between NASA and FAA on the support and funding to be provided in the aeronautical satellite area. With the key NASA communications satellite projects such as ACTS and MSAT-X progressing, this RTOP will examine advanced system concepts to be developed into full-scale technology projects and will be coordinated with MSAT-X project and related RTOPs. Areas of study are: multiservice/multifrequency satellites and platforms, satellite based data collection and interactive data networks, integrated optics/microwave/laser system, intersatellite links, etc. For the integrated aeronautical, maritime and land mobile satellite system, examined are functional and operational requirements of each service, frequency sharing techniques, system design issues to meet substantially different requirements such as per-channel EIRP, channel assignment time, security requirement, Doppler compensation, data quality, channel condition, etc. For data collection and interactive data networks, existing satellite based networks are surveyed, small customer premises terminal technology will be examined, a traffic model will be established mainly for existing data base and required orbital and frequency capacity will be determined. Intersatellite link tradeoffs will be examined with an emphasis on optical links.

W87-70309 **643-10-05**
Lewis Research Center, Cleveland, Ohio.
ADVANCED STUDIES
J. W. Bagwell 216-433-3502
(643-10-01; 650-60-26)

The objectives of this RTOP are to: (1) identify and define new applications for communication satellites; (2) define preliminary concepts, configurations, requirements and costs of alternative operational systems for new applications; (3) identify the technologies required to permit the implementation of advanced operational communication satellites; (4) formulate preliminary plans for developing the required technologies; and (5) support appropriate initiatives in the FCC, IRAC, CCIR or ITU for new space communications applications. The approach is to formulate and carry out in-house and contracted studies to meet the objectives. These studies will be of a scoping nature and will address the technical, economic and institutional/regulatory feasibility of operational systems.

Experiment Coordination and Operations Support

W87-70310 **646-41-01**
Lewis Research Center, Cleveland, Ohio.
EXPERIMENTS COORDINATION AND MISSION SUPPORT
James W. Bagwell 216-433-3502

The objective of this effort is to provide the technology, skills, and services necessary for the conduct of a meaningful experiment program using advanced communications satellite technology. The approach is to: (1) Investigate and evaluate transitional and low cost techniques for providing Earth terminal systems for the conduct of experiments using satellites incorporating advanced communications technologies. (2) Investigate wideband, high data rate communications experiments between spaceborne laser transmitters and ground or aircraft receiver platforms. (3) Supply equipment updates and operational in-house support of the communications research facilities at LeRC.

W87-70311 **646-41-02**
Lewis Research Center, Cleveland, Ohio.
APPLICATIONS EXPERIMENTS PROGRAM SUPPORT
James W. Bagwell 216-433-3502
(646-41-03; 643-10-01; 643-10-02; 643-10-03)

The objectives of this RTOP are to: (1) coordinate with other Federal agencies and public sector organizations in the development of experimental satellite communications activities for emergency/disaster communication and public service applications, (2) assist users in the transition from the NASA experimental satellites to commercial satellites where continuity of service can be assured, (3) demonstrate Applications Technology Satellite (ATS) technology and its applications for other governmental agencies and the public service sector, and (4) develop new techniques and applicable hardware for use with other appropriate Government-owned satellites. To meet these objectives in the development and transfer of satellite communication technologies, the approach will be to conduct satellite demonstrations and experiments using appropriate satellites and engage in direct interaction with potential and ongoing users of the spacecraft. This interaction will identify users' needs requiring the development of new technologies.

Advanced Communications Research

W87-70312 **650-60-15**
Jet Propulsion Laboratory, Pasadena, Calif.
MOBILE COMMUNICATIONS TECHNOLOGY DEVELOPMENT
F. M. Naderi 818-354-5095
(643-10-01; 643-10-03; 643-10-05)

This RTOP outlines a technology development program aimed at efficient utilization of orbit, spectrum and EIRP for future generation mobile satellite systems (MSS). There are five technology areas of concentration: (1) Vehicle antennas - The objective here is to develop mechanically and electronically steerable antennas which provide a moderate gain (10 dBic) and through directivity provide sufficient isolation so as to permit two or more satellites to operate in the same frequency band without interference; (2) Digital voice - The objective is to develop vocoders which can produce commercially acceptable digital voice (near toll quality) at 4800 bps rate; (3) Digital modem - This activity is aimed at developing a bandwidth efficient modem which in conjunction with the above mentioned vocoder can transmit 4800 bps voice in a 5 kHz power limited mobile satellite fading channel; (4) Network architecture - The objective is to investigate multiple access and network management protocols and standards which efficiently utilize the resources of an integrated voice and data mobile satellite network; and (5) Channel characterization - This effort is aimed at characterizing the mobile satellite channel through propagation experiments and modeling. The above activities are accomplished through in-house JPL effort and a mix of industry and university contracts. A series of experiments is being planned to test the technical and operational validity of the equipment being developed. As the above technologies are developed and validated, they will be phased into the evolving mobile satellite network and indeed will accelerate its initial introduction.

W87-70313 **650-60-20**
Lewis Research Center, Cleveland, Ohio.
SPACE COMMUNICATIONS SYSTEMS ANTENNA TECHNOLOGY
James W. Bagwell 216-433-3502

The objectives are to conduct Supporting Research and Technology development on antenna systems and components for advanced geostationary communication satellites and supporting Earth terminals. Previous efforts under this RTOP have resulted in the design, fabrication, and testing of POC models of both ground and satellite antennas. Current efforts will involve the study, design, fabrication, and testing of advanced antenna systems and components using monolithic microwave integrated circuit

(MMIC) devices for applications requiring increased performance and reduced costs. Requirements for future systems will also be assessed. The emphasis will be on identifying and then applying and focusing available MMIC device technology in those areas where impact is both desirable and feasible in the near term.

W87-70314 **650-60-21**
Lewis Research Center, Cleveland, Ohio.
SATELLITE SWITCHING AND PROCESSING SYSTEMS
James W. Bagwell 216-433-3502
(650-60-20; 650-60-22; 650-60-23)

The object of this RTOP is to develop the switching technology for the routing of signals (message traffic) aboard multibeam, multichannel communications satellites and accompanying technology for cost effective implementation of Earth terminals. To develop spectrally efficient, high data rate modulation technology. To develop low to medium data rate adaptive modem technology. To develop high performance components for architecturally advanced spaceborne communications processing and routing systems. Work includes: (1) multiple contracts to develop advanced modulation technology and burst demodulators for the space and ground segments using bandwidth efficient concepts and cost reducing techniques, (2) a contract for high speed, power efficient serial to parallel/serial converters using GaAs technology, (3) multiple contracts to develop low to medium rate demodulators that are adaptive to a broad set of practical and desired set of modulation types, and (4) high speed decoder development.

W87-70315 **650-60-22**
Lewis Research Center, Cleveland, Ohio.
RF COMPONENTS FOR SATELLITE COMMUNICATIONS SYSTEMS
James W. Bagwell 216-433-3502
(650-60-23)

The objectives are to perform supporting research and technology development in the area of space related RF components including power amplifiers, low noise receivers, and other components identified as required for the effective application of 30/20 GHz and other frequency bands. Current efforts are aimed at improvements in performance of 20 GHz TWT's, 20 GHz low noise receivers, and solid state power amplifiers and devices, By means of both contracted and in-house efforts. the approach is to develop analysis and synthesis techniques for the above space program components; apply the developed techniques to determine the basic characteristics of components meeting specified requirements; fabricate experimental components; and test and evaluate fabricated components.

W87-70316 **650-60-23**
Lewis Research Center, Cleveland, Ohio.
COMMUNICATIONS LABORATORY FOR TRANSPONDER DEVELOPMENT
James W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22)

The objectives are to design and develop a laboratory test facility to be used to test communication system components and subsystems, and to provide laboratory simulations of TDMA multibeam satellite communications systems; to further develop prototype ground terminal systems for use with advanced communication satellites; and to design, develop, and test 30 GHz uplink, frequency translator and 20 GHz downlink communications system, including transmitting and receiving ground terminals, and satellite segments. Continuous bit stream rates of nominally 27.5 Mbps and 220 Mbps will be used to modulate the links. End-to-end calculations will be made. Software simulation results will be compared with the hardware simulation results. Upon completion, network control methods will be added and burst data transmissions will be tested and evaluated in both hardware and software. Specific testing in support of the ACTS Program will be carried out as the need is defined.

W87-70317 **650-60-26**
Lewis Research Center, Cleveland, Ohio.
ADVANCED STUDIES
J. W. Bagwell 216-433-3502
(643-10-05; 650-60-20; 650-60-21; 650-60-22; 650-60-23)

The objective of this RTOP is to establish the requirements/rationale and provide a focus for NASA's communications technology program consistent with the overall goals, objectives and thrusts of NASA's Communication Program. The strategy is to: (1) assess current and future telecommunications needs and opportunities; (2) assess applications, concepts and configurations to meet those needs/opportunities; (3) define technology developments and experiments needed to enable/realize new or enhanced satellite applications and systems; and (4) define and develop advocacy for suitable advanced communications technology development programs and experiments to be undertaken by NASA. The approach is to conduct in-house and contracted studies to assess needs, determine system requirements, and define future satellite services and systems (both space and ground segments) requiring advanced communications technology. The output from these studies is used to plan and guide future communications technology development.

W87-70318 **650-60-26**
Goddard Space Flight Center, Greenbelt, Md.
ACTS/LASER COMMUNICATIONS EXPERIMENT: LASER INTERSATELLITE COMMUNICATIONS PROOF-OF-CONCEPT (POC) DEVELOPMENT
Lois O. Caudill 301-344-5608

The objective of this RTOP is to support the Advanced Communications Technology Satellite/Laser Communication Experiment (ACTS/LCE). The ACTS/LCE is a joint NASA/MIT-Lincoln Laboratory program which has the goal of placing a laser communication terminal on the ACTS spacecraft to demonstrate and test both coherent (MIT) and non-coherent (GSFC) laser communication technology. The non-coherent laser communication technology was developed under the POC phase (FY82-FY86) of the RTOP. The GSFC has the responsibility to develop and deliver to the MIT-LL the flight hardware necessary to carry out the non-coherent portion of the ACTS/Laser Communication Experiment. The GSFC portion of the ACTS Laser Communications Experiment is known as the Direct Detection Laser Transceiver (DDLT). This RTOP will fund both the flight segment and a portion of the ground segment of the DDLT.

Information Systems

W87-70319 **656-11-01**
Jet Propulsion Laboratory, Pasadena, Calif.
SAIS TESTBED PLANNING
J. Urena 818-798-5997

The Science and Applications Information System (SAIS) Test Bed Program is an initiative under the SAIS to systematically employ user expertise as part of the SAIS systems engineering process. This activity will actively engage the user community at NASA, academia, and industry in the task of investigating, developing, and validating functional requirements for the design of the space station. The proposed approach consists in the systematic test and evaluation of end-to-end system technologies and operational procedures through rapid prototyping and test beds. The exercise of these test beds by the user community will serve to assess the feasibility of new technologies and their application to the SAIS, and provide the ground to validate new Telescience operational concepts and research analysis procedures. Initial activities include the development of a SAIS Test Bed Program Plan, coordination of planning and concept development between the science community and computer science disciplines in the identification of test bed areas, and of requirements for technology applications and evaluations.

W87-70320 **656-11-02**
Jet Propulsion Laboratory, Pasadena, Calif.
STANDARD FORMAT DATA UNIT
E. Greenberg 818-354-3387

This RTOP supports the continued development of the Standard Format Data Unit (SFDU) concept. The SFDU concept is focused on the establishment of standardizable techniques for identification, aggregation and description of space acquired data. This activity is coordinated with the activities of the Consultative Committee for Space Data Systems (CCSDS) and provides a basis for NASA recommendations on the establishment of an international standard. The SFDU concept focuses on providing the methods and mechanism for: (1) establishing data product specification standards (i.e., construction techniques), (2) establishing standardized data products (i.e., secondary headers, status reports), (3) establishing data administration/control services, and (4) development of standard data services (i.e., software support services for data transport, data aggregation, and data presentation). This concept provides the foundation for the interchange of data between heterogeneous data systems to support the transfer of data between NASA data facilities and distributed data users. In addition the concept supports the development of selected standard data products for exchanging data between NASA data facilities (i.e., keyword records for data catalogs).

W87-70321 **656-11-02**
Goddard Space Flight Center, Greenbelt, Md.
STANDARD FORMATTED DATA UNIT - CCSDS PANEL 2
J. I. Vette 301-344-7354

The main objective of this work is to reduce the costs of finding and processing the diverse space data sets that are required to do multi-mission and multi-disciplinary research. This will be pursued by working vigorously as part of Panel 2 of the Consultative Committee for Space Station Systems (CCSDS). The work of this panel is concerned with data interchange structures and the Standard Formatted Data Unit (SFDU) concept is the most promising approach to solve the stated problem. The final products of CCSDS are Recommendations, based on technical considerations of its panels, that permit each member agency (NASA, ESA, DFVLR, CNES, NASDA, ISRO, and INPE) to write standards. The SFDU approach involves defining a flexible structure and construction rules so that all digital data sets which are interchanged are incorporated into this structure. In addition, the information needed to describe and work with the data set in question must be registered at a Control Authority (CA) and the material must also be available there. Each agency is expected to set up a hierarchy of CAs and the SFDU structure will provide the pointer to the proper CA for the data set. The final step of the process is to have the information above be written in a data definition language (DDL) that can be interpreted by the user's computer. In this way the user will have direct access to the foreign data set without having to write any software and can immediately begin applying his application software to this data. Once standards for SFDUs, CAs, and DDLs are in place, this mechanism/system should reduce costs significantly. Panel 2 is planning to complete four documents in FY87 provided adequate support is available. The first of these is a report describing space data systems operations using SFDUs which will provide the overview. The second document will be the final CCSDS product for SFDU structure and construction rules, an approved Recommendation. Control Authority Procedures will be published as a draft Recommendation, which means that it will undergo each agency's review. The DDL document rounds out the list and its level of maturity is hoped to be at the draft Recommendation stage.

W87-70322 **656-13-25**
Goddard Space Flight Center, Greenbelt, Md.
MPP MAINTENANCE/OPERATIONS
J. R. Fischer 301-286-5184
(656-20-26; 656-44-06; 656-44-10)

The objectives are to: maintain the MPP hardware and system software available to its user community; maintain the MPP unique system software developed by OAST; maintain selected applications library software developed by MPP users; and maintain and operate the MPP and its VAX host computer. A baseline effective and reliable MPP system will be made available.

W87-70323 **656-13-50**
Jet Propulsion Laboratory, Pasadena, Calif.
PILOT LAND DATA SYSTEM
E. P. Paylor 818-354-2867
(677-41-24; 656-62-02; 656-11-01; 656-13-40)

The objective of the Pilot Land Data System (PLDS) project is to develop and implement a prototype state-of-the-art data and information system to support research in the land related sciences that will lead to a permanent research tool. The capability is to be general, inter-center, and be based, to the extent possible, on existing technology. The purpose of this particular task is to coordinate the PLDS work ongoing at JPL, funded directly by GSFC, and provide support to the PLDS system engineering technical area for developing system and science requirements and for developing Build 1. PLDS is a multi-NASA center activity led by GSFC. JPL personnel will continue to participate in the PLDS Design and Science teams. JPL personnel will maintain an up-to-date set of science requirements and jointly determine the functional requirements before any implementation and evaluate the results. Liaison and coordination with other ongoing projects, such as the AVIRIS/Imaging Spectrometer, high-dimensionality processing, SAR, hypercube, EOIS, SAIS, and the other Pilots will be maintained.

W87-70324 **656-13-50**
Ames Research Center, Moffett Field, Calif.
PILOT LAND DATA SYSTEM (PLDS)
William Likens 415-694-5596
(656-42-01)

Additional T43's for Ames Research Center (ARC) work on this RTOP are being submitted by Goddard Space Flight Center (GSFC). The objective is to build a prototype distributed data system for processing land science data. This system would be built to explore issues in constructing a full-scale system for supporting all NASA land science data processing being carried out at NASA centers and associated universities. This work is managed by GSFC. The ARC responsibilities are for establishment of a computer network, development of user documentation, and for appropriate system interface software and hardware. The objective of the Pilot Land Data System is to emphasize link-up of existing computer facilities currently used in land science data processing.

W87-70325 **656-20-26**
Goddard Space Flight Center, Greenbelt, Md.
MPP SOFTWARE (SYSTEMS AND APPLICATIONS)
J. R. Fischer 301-286-5184
(656-13-25)

The objective is to assist the Massively Parallel Processing (MPP) Working Group projects to be completed successfully. The approach is to develop MPP applications library routines as well as features of the MPP system software, as requested by the Working Group. An MPP user support office and two user conferences are also provided.

W87-70326 **656-25-01**
Jet Propulsion Laboratory, Pasadena, Calif.
EOS HIGH RATE DATA SYSTEM TESTBED
D. A. Nichols 818-354-9012
(656-62-01; 404-79-02)

This RTOP establishes the beginning of a testbed program which will address issues of accommodating extremely high data rate and volume instruments in the Earth Observing System (EOS) Data and Information System (EOSDIS). The approach includes the important concept of utilizing the EOS pre-cursor missions (e.g., SIR-C,D and SISEX) in an evolutionary preparation for EOS operations. There are four major objectives of the testbed program: (1) design and validate approaches to highly rate-sensitive functions, such as instrument sequence planning; (2) develop the capabilities necessary to control the High Resolution Infrared

Sounder (HIRIS) and Synthetic Aperture Radar (SAR) instruments; (3) support the EOSDIS design activity by providing prototyping and critiques of planned rate-sensitive functional elements and interfaces; and (4) provide an environment conductive to the constructive, iterative involvement of the scientific users of these high data rate experiments and facilities. The approach to be taken by the testbed program in meeting these objectives will be to identify prioritized tasks as guided by the existing data system and mission designs, maximize the use of on-going data system development activities and precursor flight opportunities, and develop experiments, demonstrations, and prototypes to take advantage of those activities and opportunities. The first major testbed activity will be a demonstration of telescience (which includes near-real time remote instrument control), during the Shuttle Imaging Radar (SIR)-C mission, utilizing extensions to the SIR-B/SIR-C data management system. Telescience is considered a high priority because it is an essential element of high volume data rate management strategies, utilizes the Earth Science Network, and is highly rate-sensitive.

W87-70327 **656-31-05**
Goddard Space Flight Center, Greenbelt, Md.
NASA CLIMATE DATA SYSTEM
Paul H. Smith 301-344-5876

The NASA Climate Data System (NCDS), previously known as the Pilot Climate Data System (PCDS), was first implemented in FY-82 as the Pilot Climate Data Base Management System. In FY-83, data manipulation utilities and graphics tools were added to the initial catalog, inventory, and data access capabilities, and direct support for scientific researchers began. During FY-84, this support was expanded to meet the needs of specific user groups within the Space and Earth Sciences Directorate (formerly the Applications Directorate) of GSFC. In FY-85, this support was also provided for several researchers outside of Goddard Space Flight Center (GSFC), including university scientists. During FY-86, a transition plan from the pilot system development phase to the operational research support phase was initiated in conjunction with the Earth Science and Applications Division. During this transition, PCDS has continued to support the specific science user groups, expanding the direct support of specific universities. During FY-87, this transition will be completed while continuing support for specific science user groups (in particular a few universities), sharing the operations and maintenance of the computer facility on which the NCDS resides, maintaining system software and databases, and providing additional software tools and data sets. In order to support increasing needs of the current users and additional users from the science user groups, the NCDS will also need to dramatically increase the available computer resources, especially on-line storage and computing power.

W87-70328 **656-42-01**
Ames Research Center, Moffett Field, Calif.
WORKSTATION RESEARCH AND DEVELOPMENT
W. C. Likens 415-694-5596
(656-13-50)

Scientific workstations are small microcomputer systems tailored for specific scientific data processing needs. Typically, these are small single user systems. Small microcomputer systems dedicated to supporting a single scientist are becoming more prevalent due to the low cost of new microcomputers. A major task of NASA workstation R&D efforts is to develop and implement NASA science specific software on commercially available workstations. The objective of this work is to enhance productivity of OSSA sponsored workstation R&D efforts. This would be accomplished by minimizing duplication of effort between workstation R&D groups. Resources freed in this manner can then be tasked to further efforts that might not otherwise be accomplished. To be successful, this effort will require a high degree of joint planning and sharing of results. The means for effecting this will be an intercenter workstation R&D committee, and a series of planning and information exchange workshops.

W87-70329 **656-44-10**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED SYSTEMS ARCHITECTURE
Y. C. Lu 301-344-9510

The objective is to develop portable software to establish a distributed image processing environment across microcomputer based workstations, minicomputers and super computers, and to provide functions needed to support advanced telescience for space station information processing system. The approach is to: utilize the Transportable Applications Executive (TAE) as standard interfaces that are user-friendly to allow access to image processing environment by geographically and scientifically diverse users throughout the multi-disciplinary science community; create a software link between the microcomputer workstations, the minicomputers, and the super computers so that a user at the workstation can conveniently perform image processing on either the local workstation, the mini, or the super computer; investigate need for decentralizing the TAE catalog manager to facilitate file manipulation across all computers; implement selected image processing functions (already on a mini) on a micro computer and a super computer; improve the portability of the Image Analysis System (formerly Land Analysis System) and port the system to different computers and to run on different host operating environments; and continue user support through the TAE support office. Expected results for FY-87 are: implementation of a prototype distributed multi-disciplinary image processing system on three types of computers, and conversion of image processing system and its subsystems to new architectures to improve transportability.

W87-70330 **656-62-02**
Jet Propulsion Laboratory, Pasadena, Calif.
HIRIS DATA PROCESSOR
J. E. Solomon 818-354-2722
(506-54-55)

The objective of this task is the implementation of hardware and software technologies required for support of the Earth Orbiting Satellite (EOS) High Resolution Imaging Spectrometers (HIRIS) system with respect to both on-board and ground data processing. Given the extremely high instrument data rate (980 MBits/sec), and the resulting large volumes of data, concurrent processing technology will be required to address both on-board signal processing needs and ground data system processing requirements. A major objective of this work is the implementation of a concurrent processing environment within which to evaluate both algorithmic and systems issues associated with HIRIS on-board and ground data processing requirements. The approach to be taken in this work consists of the following three elements: (1) Implementation of a combined Multiple Instruction Stream/Multiple Data (MIMD)/Single Instruction Stream/Multiple Data (SIMD) concurrent processing environment; (2) Development of data compression and information extraction algorithms suitable for HIRIS on-board implementation; (3) Evaluation of hardware requirements for ground data processing through Level 3; and (4) Demonstration of end-to-end HIRIS processing utilizing Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data.

W87-70331 **656-80-01**
Jet Propulsion Laboratory, Pasadena, Calif.
PLANETARY DATA SYSTEM
J. T. Renfrow 818-354-6347
(656-11-01; 656-13-40; 656-13-50; 155-20-70; 656-44-11)

The overall objective of this RTOP is to conduct evaluations of technologies which can be used in solving the data problem of the planetary science community and to do these evaluations within Science Testbeds which are run by working planetary scientists. The detailed objectives of this RTOP are to: develop system concepts and evaluate these concepts and also appropriate technologies to support the archiving and accessing of planetary science data by the planetary science community; have the actual users of the technologies try out and evaluate at their home institution the technologies being studied and develop and demonstrate the efficacy of data administration, data format, and

data nomenclature standards for use across the full spectrum of future planetary missions and data restoration activities. To meet these objectives a three fold approach will be used. This includes development of system components and applicable technologies to test and validate functional and performance requirements and serve as testbeds for technology. These system and technologies components will be developed in such a way that the ability to incorporate these components into the operational Planetary Data System (PDS) is maximized. The scientists involved in the project actually will use the testbeds to perform science functions. Development, validation, and demonstration of data standards in the development of optical disks and planetary science data catalogs and data bases are presented.

Climate Research

W87-70332 **672-21-99**
Ames Research Center, Moffett Field, Calif.
AEROSOL AND GAS MEASUREMENTS ADDRESSING AEROSOL CLIMATIC EFFECTS
R. F. Pueschel 415-694-5254

The goal is to advance the understanding of aerosol effects on climate, and to focus especially on the effects of major volcanic eruptions and major tropospheric hazes such as the Arctic haze. This is done by collecting, analyzing, interpreting and publishing data on the aerosol particles and precursor gases that constitute or form the hazes of interest. The U-2, ER-2, C-130 and the DC-8 are used as platforms to access the subject aerosols. The physical and chemical properties of the aerosol particles are determined in-situ with commercial and in-house-developed sensors. Optical properties of the hazes are derived from these measurements invoking light extinction theory.

W87-70333 **672-22-06**
Goddard Inst. for Space Studies, New York.
EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES
William Rossow 212-678-5567
(672-10-02)

The objective is to test cloud analysis algorithms, particularly that used as the International Satellite Cloud Climatology (ISCCP) operational algorithm, for cases which present difficult problems such as the polar regions, and develop new cloud analysis techniques. The approach is to test ISCCP results in polar regions against available aircraft data and multispectral radiative analysis of Advanced Very High Resolution Radiometer (AVHRR) data. Test ISCCP results by radiative model comparisons to First International Satellite Cloud Climatology Regional Experiment (FIRE) observations of cirrus and marine boundary layer clouds; develop methodologies to infer cloud-radiative feedbacks from ISCCP data; improve understanding of utility of current and planned satellite observations for determining polar region cloudiness; and infer cloud-radiative feedback from ISCCP climatology.

W87-70334 **672-22-99**
Ames Research Center, Moffett Field, Calif.
RADIATIVE EFFECTS IN CLOUDS FIRST INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY REGIONAL EXPERIMENT
F. P. J. Valero 415-694-5510

The interaction of radiation with clouds plays a fundamental role in the Earth's energy budget. The objectives of this work are to study the measurement and modeling of the interaction of radiation and clouds - including radiative flux divergence profiles, optical depths, total/diffuse radiation field determines and particle size distribution in stratus and cirrus clouds. It is a fundamental objective of this work to validate satellite-acquired radiative data. Measurement will be made using aircraft as instrument platforms during the First International Satellite Cloud Climatology Regional Experiment (FIRE) deployments. From the above measurements, the significant radiative energy parameters are determined and used in radiative transfer modeling to validate model prediction.

W87-70335 **672-31-02**
Ames Research Center, Moffett Field, Calif.
AEROSOL FORMATION MODELS
O. B. Toon 415-694-5971
(672-32-99)

The objectives of the work are: (1) to simulate the ambient stratospheric aerosol layer and the El Chichon volcanic cloud, (2) to extend the knowledge gained by studying the El Chichon cloud to larger eruptions, and (3) to begin to play a role in NASA studies of water clouds and their effects on the radiation balance. The volcanic cloud and ambient simulations will be compared with observations, and will be used to create input data sets for climate models, to test data sets for internal consistency and to better determine the physics and chemistry of the stratosphere. The model offers the best means of extrapolating the knowledge gained from the El Chichon eruption to other eruptions of greater or lesser magnitude. A three-dimensional model of stratospheric aerosols was developed which includes all the physics needed to treat dense volcanic clouds and the ambient stratospheric aerosols as well as the chemistry needed to simulate the ambient atmosphere. A chemistry package is being developed to simulate the chemistry in dense clouds. Also, considerable work was done to obtain a wind field from the 1982 NMC data that will be suitable for transport studies and a radiation code was developed to drive a stratospheric dynamics model that will be used to investigate radiative interactions between the volcanic cloud and stratospheric winds.

W87-70336 **672-31-12**
Goddard Inst. for Space Studies, New York.
EXTENSIONS AND TESTING OF THE HYDROLOGIC PARAMETERIZATION IN THE GISS ATMOSPHERIC GCM
Anthony D. Del Genio 212-678-5588

The overall objective of this work is to test and improve the capability of the Goddard Institute for Space Science (GISS) general circulation model (GCM) to reproduce critical aspects of global hydroclimatology, via the development of new diagnostic methods for evaluating the cycling of moisture in the model and the implementation of subgrid-scale fluctuations in the model's ground hydrology parameterization. Principal elements of the approach are: (1) Development of a tracer model version of the GCM which can follow the trajectories of atmospheric water vapor molecules from source to sink locations. (2) Comparison of model-simulated precipitation depth, duration, and storm intervals to observations at selected locations. (3) Formulation and testing of the effects of subgrid-scale soil moisture variations in the GCM ground hydrology parameterization based on observed precipitation probability density functions and field studies of storm catchment areas.

W87-70337 **672-32-02**
Ames Research Center, Moffett Field, Calif.
CLIMATE MODELING WITH EMPHASIS ON AEROSOLS AND CLOUDS
T. P. Ackerman 415-694-5233
(672-31-99)

A coordinated set of theoretical, laboratory, and field investigations of the chemical and radiative properties of clouds, natural (e.g., volcanic), and man-made atmospheric aerosol particles are conducted in order to assess their impact on regional and global climate. The field investigations are intended to provide complementary information on clouds and aerosols to that being obtained from spacecraft platforms (e.g., SAM, SAGE II AND SME) so as to insure that a comprehensive set of properties is gathered for climatic analyses. The theoretical and laboratory tasks are directed at interpreting and utilizing the data sets to perform the desired climatic assessments. The centerpiece of the field investigations is a set of coordinated experiments which are flown together on an appropriate aircraft platforms. Both theoretical modeling and laboratory studies are used to define the mechanisms of aerosol and cloud formation, to provide hypotheses that can be tested by the field investigations, and to provide ultimately predictive tools. Theoretical investigations involving radiative

transfer, dynamics, and formation are utilized for making the climatic assessments.

W87-70338 **672-50-99**
Ames Research Center, Moffett Field, Calif.
AMES MULTI-PROGRAM SUPPORT FOR CLIMATE RESEARCH
R. Pueschel 415-694-5254
(672-21-99; 672-31-99; 672-32-99)

The objective is to consolidate Ames Multi-program Support (MPS) costs for the Ames 672- UPN so that charges need not be made against individual RTOPs in the UPN. The 672- UPN supports the study of atmospheric aerosols through observational and theoretical tasks. These include assessments of the impact of stratospheric aerosols on climate, understanding the role aerosols play in the chemistry stratosphere, evaluating the aerosol components of pollution, and determining their composition and mode of formation. The 672-22-99 is an addition to this year's consolidation of MPS charges.

Stratospheric Air Quality

W87-70339 **673-42-01**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF TROPOSPHERE-STRATOSPHERE EXCHANGE
L. Pfister 415-694-5491

The overall goal of this work is to improve the understanding of the role of small scale motions in stratosphere-troposphere exchange in the tropics. Specifically, analysis will be made of aircraft, radiosonde, and satellite data from the 1977 and 1980 NASA field experiments in Panama and the 1987 NASA field experiment in Micronesia to: (1) examine the structure of ozone, temperature, and water vapor within, around, and above cumulus anvils; (2) establish the presence, during the experimental period, of various potential mechanisms of exchange, such as direct injection by cumulus, gravity wave fluxes, and turbulent fluxes; and (3) evaluate quantitatively, if possible, the mass of air transferred by these mechanisms during specific transport events.

W87-70340 **673-61-02**
Jet Propulsion Laboratory, Pasadena, Calif.
MESOSPHERIC THEORY
R. W. Zurek 818-354-3725

The goal of this task is to better understand the interaction of photochemistry and mass transport in the terrestrial upper atmosphere. The approach is to develop in collaboration with Y. Yung (Caltech) and M. Allen (JPL/CIT) a 2-D interactive model containing coupled chemistry and transport relevant to the stratosphere and mesosphere. This model would then be used to simulate and interpret the observed distributions of photochemically important atmospheric trace constituents observed from airborne and spaceborne platforms.

W87-70341 **673-61-03**
Ames Research Center, Moffett Field, Calif.
STRATOSPHERIC DYNAMICS
R. E. Young 415-694-5521

The objectives of this research are to increase the understanding of the dynamics, thermodynamics, and composition of the Earth's stratosphere, and to investigate the mechanisms by which trace species are exchanged between troposphere and stratosphere. The research will involve a combination of theoretical and observational studies. Global and mesoscale circulation models will investigate transport and exchange processes. Satellite data analysis will be used to characterize wave and transport phenomena in the stratosphere. Meteorological and diagnostic analysis will be conducted in support of aircraft measurement programs, such as the Troposphere-Stratosphere Exchange experiment.

W87-70342 **673-62-04**
Goddard Inst. for Space Studies, New York.
CHEMISTRY OF STRATOSPHERE
Michael Prather 212-678-5625

The proposed research should contribute to the knowledge of chemical processes in the stratosphere. It may be expected to resolve some of the current discrepancies between observations and theoretical models. Task 1 consist of global CH4-CO coupled system: continued development and refinement of the 2-D diagnostic model for OH, CO and CH4, including estimates of the impact of Nuclear Microprobe for Hydrogen (NMHCs) on global atmospheric chemistry. The model will be used to study the cause of trends in CO/CH4 over the last two centuries. Task 2 consists of transients in stratospheric chemistry: modeling the photochemical environments observed from balloon soundings of the stratosphere, investigating the thin layers observed in H2O profiles. Task 3 consists of Ultraviolet (UV) transmission in the stratosphere: re-evaluation of UV transmission in the S-R bands of O2, using laboratory data and high resolution solar spectra. This work should more clearly define photolysis of O2 and NO in the stratosphere.

W87-70343 **673-64-04**
Goddard Inst. for Space Studies, New York.
STRATOSPHERIC CHEMISTRY AND TRANSPORT
Michael Prather 212-678-5625

The proposed research emphasizes the 3-D transport of chemically active species in the stratosphere. Work will center on the development of the 21-layer chemical transport model for the stratosphere. Task 1 consists of 21-layer tracer model: development and validation of stratospheric chemical tracer model based on experience with similar tropospheric models. The chemical model will be limited to photolytic destruction of species such as CFCs and N2O. Comparison will be made with observations. Task 2 consists of stratospheric chemistry: parameterization of a complete ozone chemistry for use in the stratospheric tracer model. Task 3 consists of perturbated atmospheres: relying on the 21-layer General Circulation Model (GCM) simulation of CO2 and O3 perturbations to the stratospheric circulation, using chemicals to assess the impact on lifetimes of long-lived tracers and on ozone.

Space Processing Science and Spacelab Payload Development

W87-70344 **674-21-06**
Langley Research Center, Hampton, Va.
ELECTRONIC MATERIALS, VAPOR GROWTH AND LOW-G GRAVITY TECHNIQUES
A. L. Fripp 804-865-3777
(694-80-70)

The objective of this research is to gain a better understanding of the role of fluid dynamics in the growth of crystals by vapor transport. Both theoretical and an experimental investigation will be conducted. Model materials may be used to simulate actual crystal growth systems. This work is of a fundamental nature and will support the science base needed to design space flight experiments.

W87-70345 **674-21-08**
Marshall Space Flight Center, Huntsville, Ala.
ELECTRONIC AND OPTICAL MATERIALS
I. C. Yates 205-544-1997

In any crystal growth system, an important problem is that the compositional and/or thermal fluctuations in the fluid phases cause compositional inhomogeneities and defects in the growing crystal. Where these fluctuations are caused by convection and sedimentation, they can be reduced in low gravity. Therefore, the major objectives of this crystal growth program are to: (1) understand the role of gravity and determine limitations in Earth's gravity; (2) determine and demonstrate advantages to be obtained by growing crystals in space; and (3) apply the findings to help solve problems in the crystal growth of electronic and optical materials.

The types of growth that will be explored in this program include melt, solution, vapor, and float zone growths. Crystal growth by solidification from the melt is the most widely used technique for high technology single crystalline materials. The success of the technique depends on the control of the composition, temperature, and morphology of the solidification interface. Advantages of this technique include the control it provides over the temperature of growth. In the vapor approach, there are two distinct mechanisms for growing a crystal: physical vapor deposition and chemical vapor deposition (CVD). Floating zone crystal growth is accomplished by supporting a polycrystalline rod at both ends; melting a portion of it with a moving heater, and growing a crystal behind this zone. Finally, growth from aqueous and ternary solutions proceeds with the incorporation of solute into the growing crystal interface and offers flexibility for the choice of growth temperatures.

W87-70346 **674-22-05**
Lewis Research Center, Cleveland, Ohio.
COMBUSTION SCIENCE
Kurt Sacksteder 216-433-2857

The objective of the Combustion Science program is to obtain an understanding of fundamental combustion phenomena where low-gravity analysis and experimentation can be of use in: (1) isolating the gravity related mechanisms; (2) determining the influence of mechanisms normally obscurred by gravitational effects; (3) creating unique system configurations that provide favorable symmetries or boundary and initial conditions; or (4) determining the controlling mechanisms of low-gravity systems for in-space applications. The Microgravity Combustion Science Discipline Working Group provides advice to focus the effort on those areas of Combustion Science where maximum benefit can be anticipated through low-gravity research. Principal Investigators from the academic and industrial communities and from NASA LeRC are chosen to develop analytical or numerical models of selected combustion problems. Using the results of theoretical analysis, a Principal Investigator defines and performs normal-gravity and low-gravity experiments to obtain scientific data within the constraints of ground-based laboratories. Experimental and theoretical results are reconciled and evaluated to determine if together they provide an accurate model of the combustion phenomena under study. When the limitations of ground-based laboratories preclude conclusive testing of theoretical analysis, the Principal Investigator defines experiments requiring the long-duration low-gravity environment of space. Additional analyses and ground-based experiments are performed to determine the nature and feasibility of the apparatus required for the space experiment and a specification of the data to be obtained using the apparatus. The Principal Investigator prepares a Science Requirements Document and participates in the preparation of a Conceptual Design of a space experiment which together will summarize the justification and feasibility of that experiment.

W87-70347 **674-23-01**
Lyndon B. Johnson Space Center, Houston, Tex.
BIOTECHNOLOGY RESEARCH
Dennis R. Morrison 713-483-4086
(694-01-01)

This research will establish the data base for formulation of new Biological separation flight experiment proposals, and establish appropriate ground control experiments. These objects are designed with five objectives: (1) Gain a better understanding of basic science questions uncovered by microgravity separations, cell culture and cell product separation direct from various culture media; (2) Define and screen new candidate cell types or cell products for possible electrophoretic separations or cell culture experiments using the Continuous Flow Electrophoresis System (CFES) or the Cell Culture Bioreactor; (3) Study unique bioprocess limitations caused by gravity dependent phenomena and determine practical limits of improvements expected by biological processing in microgravity; (4) Explore new research applications of the biological target materials and new technology innovations; and (5) Define and develop analytical methods and requirements for Biotechnology research facilities planned for the U.S. Space Station. The JSC Bioprocessing Laboratory will perform portions of the research and coordinate the projects among several major universities and medical schools. Access to the CFES Unit will be provided by the McDonnell Douglas Astronautics Co. (MDAC) at the Bioprocessing Research Center at Houston (BRCH) via the University of Texas Health Science Center. JSC will analyze results, coordinate scientific publications, and aid Principal Investigators in using the information in the conduct of on-going flight experiments. Scientific data will be used to formulate new proposals for flight experiments or groundbased applications of the technology.

W87-70348 **674-23-08**
Marshall Space Flight Center, Huntsville, Ala.
BIOTECHNOLOGY
V. H. Yost 205-544-1998

The long-range objective is to utilize the environment of space to separate, purify or crystallize and analyze biological products. The intermediate objectives are to develop the required technology and to expand the base of knowledge involved with processing biologicals in space; to identify, evaluate and select the most promising processes; and to explore new areas of separation technology. Separation and purification procedures which have been found to produce inadequate results on the ground because of gravity-dependent problems will be investigated. More specifically, this program will: (1) determine possible advantages of the low-gravity environment for separation, purification, crystallization and characterization of biomedical materials; (2) design, develop, manufacture and test experiment apparatus to conduct experiments in low-g; (3) apply ground/flight knowledge to the improvement of bioprocessing procedures on Earth; (4) develop broad and strong collaborative interactions with research scientists; and (5) identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity. The research is directed toward answering these fundamental questions.

W87-70349 **674-24-05**
Lewis Research Center, Cleveland, Ohio.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
A. Chai 216-433-2073

The objective of the fluid physics and transport processes research related to materials science is to investigate fluids behavior and apply the knowledge to materials processes so that better understanding of these processes can be accomplished. The approach is to focus efforts in two main areas in which fluid behavior effects materials processes in a major way, i.e., transport processes and thermodiffusocapillary phenomena. Several idealized simple systems were chosen to establish initial modeling work. The goal is to confirm and refine initial modeling by numerical simulation and experimentation in-space experiments, in particular. The laboratory work and modeling activities will be directed toward the development of science requirements and conceptual design for flight experiments.

W87-70350 **674-24-06**
Langley Research Center, Hampton, Va.
PACE FLIGHT EXPERIMENTS
Joseph C. Moorman 804-865-3661

The basic purpose of the PACE (Physics and Chemistry Experiments in Space) program is to facilitate the utilization of space as a laboratory in which to carry out basic research in the areas of Physics and Chemistry. There are currently 15 experiments in the program in the areas of Fluid Physics, Critical Phenomena, Combustion, Soil Mechanics and Relativity. The objectives of this RTOP is to provide the support to these 15 experiments required to facilitate their development through the conceptual design phase and to support them through the flight development phase with Science Peer Reviews and Science Peer Advocacy.

W87-70351 **674-25-04**
Jet Propulsion Laboratory, Pasadena, Calif.
METALS AND ALLOYS
D. D. Elleman 818-354-5182

The Metals and Alloys Research and Technology Operating

Plan consists of five tasks. The principal objectives of each of the tasks are discussed below. The Electrostatic Containerless Processing Technology task objective is development of the science and technology base required for contactless positioning and manipulation of high-temperature materials using electrostatic and electrophoretic forces. Experimental and theoretical investigation is being conducted of the following systems: hybrid electrostatic acoustic positioning module, high-temperature electric pole levitator, focused radiator furnace, and the hot wall furnace for low density samples. The Containerless Studies of Nucleation and Undercooling task objectives are to utilize containerless manipulation technologies to perform: (1) undercooling and heterogeneous nucleation experiments on low melting pure metals and alloys and organic compounds and glass formers; and (2) measurements of the physical properties of undercooled melts. Experimental methods are based on acoustic levitation techniques using gaseous and liquid hosts. The Metallic Glass Research in Space task objective is to develop an experiment to determine thermodynamic properties of bulk metallic glasses over the entire undercooling region. The primary scientific objective is to measure the specific heat of undercooled bulk metallic glass systems. Other objectives include measurements of the rate of homogeneous nucleation and the evaluation of crystal-melt interfacial tension and, in the long term, development of metallic glasses into a viable industrial and commercial material. The Crystallization of Freely Suspended Spheres and Shells task objective is to conduct both ground based and reduced gravity experiments required for understanding: metal spheres used in sintered metals; silicon spheres used in solar cells; water droplets freezing in the atmosphere; and crystallization of bubbles and shells. Such geometries are important in construction of laser fusion targets and low density sintered shells which have great potential for lightweight structural materials. The Multimode Acoustic Research task objectives are: (1) to develop theoretical acoustic models of these levitation classes; and (2) to provide experimental validation of these models using research levitation devices. These new levitation principles provide us with advanced alternative methods for positioning and manipulating molten materials, which may lead to rapid cooling, separation of levitation and rotation capabilities, and the selection of arbitrary axes of rotation.

W87-70352 **674-25-05**
Lewis Research Center, Cleveland, Ohio.
METALS AND ALLOYS
Hugh Gray 216-433-3230

The objective of this project is to conduct fundamental research on the solidification of metals and alloys in order to improve our understanding of phenomena such as macrosegregation, microsegregation, dendritic growth models, and undercooling. The ultimate goal is to use this understanding to improve current or develop new theories, models and improved ground-based materials/processes. The near-term targets are: (1) to determine the role of gravity-driven convection on the problem of macrosegregation in commercial alloys, with initial tests being conducted on Pb-Sn model alloys leading towards a series of shuttle flight experiments on nickel-base superalloys; and (2) to investigate the effects of containerless processing in order to understand the influence of undercooling on resulting alloy microstructures and to evaluate the potential of bulk undercooling as a solidification process. This effort will consist of a phased approach ground based research program in laboratories, flight hardware definition, development and space experiments. This program builds on the extensive OAST R and T base in the areas of solidification processing and evaluation of advanced high temperature alloys which exists at the Lewis Research Center. This program involves focused joint LeRC/university/industry cooperative/advisory efforts.

W87-70353 **674-25-08**
Marshall Space Flight Center, Huntsville, Ala.
METALS AND ALLOYS
R. E. Black 205-544-1983

Control of the solidification of metals and alloys is keyed to gravitational effects such as buoyancy-driven convection. Thus the objectives of the study are to: (1) identify various aspects of solidification phenomena that may be affected by gravity-drive flows, (2) devise and conduct critical experiments in both increased gravity as well as in space, and (3) impact the field of metallurgy by fundamental knowledge through devising better control strategies. Multicomponent metallic systems involve a first-to-freeze component which nucleates and begins to grow, causing the composition ahead of the solidification front to change dramatically. Where it is infeasible or undesirable to provide controlled gradients for a planar solidification front, dendritic growth results. Thus, concentration is one of the more fundamental problems involved in the formation of dendrites. Directional solidification affords a degree of control because of undirectional thermal gradient can be imposed and growth rate regulated. Another important class is the monotectic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

W87-70354 **674-26-01**
Lyndon B. Johnson Space Center, Houston, Tex.
HIGH TEMPERATURE, CONTROLLED REDOX STUDIES
Richard J. Williams 713-483-2781

The objectives of this work are to provide support for the ground-based laboratory studies by those local and other investigators under the Flight Hardware (UPN 694-01) portion of the Microgravity Program. Basic laboratory capability will be maintained so that investigators planning flight experiments can conduct ground studies using proto-flight equipment. Services and supplies will be provided to local and guest investigators for experiment execution and analysis. As they are approved by Headquarters on the basis of peer reviewed proposals, researchers will be funded to conduct studies in their own laboratories and will be given access to the local facilities as required.

W87-70355 **674-26-04**
Jet Propulsion Laboratory, Pasadena, Calif.
GLASS RESEARCH
M. C. Weinberg 818-354-2690

The objective of this RTOP is to establish the scientific framework for the identification and evaluation of potential flight experiments via ground-based experimentation and mathematical modelling. In FY-87 work will be pursued in the areas of nucleation and crystallization phenomena in glasses and gel-derived glasses. The objectives for FY-87 are: (1) to continue the study of homogeneous crystal nucleation in lithium diborate glass; (2) to study surface crystallization phenomena; and (3) to investigate the competition between glass formation and phase transformation processes in gels.

W87-70356 **674-26-05**
Lewis Research Center, Cleveland, Ohio.
GLASSES AND CERAMICS
Stanley Levine 216-433-3276

The objective of this program is to identify and initiate fundamental research in the areas of glasses and ceramics. The first effort consists of a study of the effects of gravity on the combustion synthesis of ceramics and alloys. Phase immiscibility in glasses has been targeted for an in-house research effort.

W87-70357 **674-26-08**
Marshall Space Flight Center, Huntsville, Ala.
GLASSES AND CERAMICS
L. B. Gardner 205-544-1993

The objectives of this activity are to: explore novel techniques and applications for containerless processing of glasses and refractory materials; understand the limitations imposed by the gravitational field; and evolve meaningful flight experiments which extend processes beyond gravity limitations. Containerless processing in space requires low level levitation forces to compensate for microgravity acceleration and maintain position of the sample. The central reason is the elimination of extraneous effects from contact with solid containment walls. The implementation of appropriate experiments will involve the following: (1) a 31-meter drop tube at

MSFC provides 2.6 seconds of free fall for solidifying molten droplets up to several mm diameter; (2) a single axis acoustic levitator developed which uses a high-Q driver with a single resonant frequency; (3) a three-axis acoustic levitator has also been under development involving three mutually orthogonal drivers which produce a three-dimensional sound field (spherical energy well) in a tuned cavity; (4) a 10 kW electromagnetic levitator facility, which by careful coil design maximizes Grad B/B, is in use to levitate samples with a minimum of heating; and (5) aerodynamic levitation using a jet of air from a carefully designed nozzle used to suspend highly reactive samples.

W87-70358 **674-27-05**
Lewis Research Center, Cleveland, Ohio.
MICROGRAVITY SCIENCE RESEARCH LABORATORY
L. Greenbauer-Seng 216-433-5013

The objective of this project is to operate and maintain a dedicated, well equipped Microgravity Materials Science Laboratory (MMSL). This laboratory will provide visiting scientists, from industry and universities, access to experimental equipment configured to simulate Shuttle flight-type hardware. The availability of this experimental equipment and technical support provided by MMSL staff will help the scientist obtain a better understanding of their materials experiment in a lg (low gravity) environment. Needs for materials characterization, advanced computations, mechanical testing, etc., will be met using existing Lewis research capabilities. The laboratory will be a site for visiting scientists to conduct experiments as precursors to the use of other ground-based microgravity facilities, such as the drop towers and research aircraft, or in preparation to qualify an experiment for a NASA Space Shuttle flight.

W87-70359 **674-28-05**
Lewis Research Center, Cleveland, Ohio.
GROUND EXPERIMENT OPERATIONS
Jack Salzman 216-433-2868

The objective of the Learjet/Drop tower support effort is to provide the manpower, equipment and facility support necessary to perform in-house reduced gravity experiments. Experiments are conducted to support both principal investigator studies and LeRC (Lewis Research Center) in-house studies in combustion science and fluid physics.

W87-70360 **674-28-08**
Marshall Space Flight Center, Huntsville, Ala.
GROUND EXPERIMENT OPERATIONS
R. E. Black 205-544-1983

This RTOP covers work in the area of defining, developing, and conducting experiments using the low-gravity capabilities of the drop tube, drop tower, KC-135, and F-104 aircraft. Such experiments may be in themselves complete investigations to develop new knowledge or to prove theories, or they may serve a precursors for more extensive experiments to be conducted in space. This RTOP also includes studies and experiments to define the effects of various levels and durations of acceleration perturbations on microgravity experiments.

W87-70361 **674-29-04**
Jet Propulsion Laboratory, Pasadena, Calif.
MICROGRAVITY SCIENCE AND APPLICATIONS PROGRAM SUPPORT
T. G. Wang 818-354-6331

The objective of this RTOP is to develop and implement program plans for the Microgravity Science and Applications program. These plans will provide the guidance for ground-based experiments to develop a data base for future planning of space operations. The Jet Propulsion Lab is already working on this plan and the effort will be expanded.

W87-70362 **674-29-08**
Marshall Space Flight Center, Huntsville, Ala.
CONSULTING AND PROGRAM SUPPORT
J. M. Price 205-544-1979

The objectives of this RTOP are: to provide the necessary management and support manpower to implement the Microgravity Science and Applications (MSA) research and technology development effort; and to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purpose of: making them aware of the research opportunities offered by the MSA program; stimulating their interest and active involvement in the program; gauging their response to the scientific results being obtained by the program; identifying research areas in which the program should concentrate; initiating in-house research activities in selected topics pertinent to the MSA program; and evaluating the ongoing research effort. MSFC will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through working groups, seminars and workshops, science reviews, and a visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented and disseminated to the science communities in the form of a published bibliography and catalog of tasks.

Geodynamics Research and Technology Development

W87-70363 **676-30-05**
Jet Propulsion Laboratory, Pasadena, Calif.
EARTH STRUCTURE AND GEOPHYSICS
C. F. Yoder 818-354-2444

A wide range of geophysical investigations are proposed, including analysis of tectonic processes (focused on brittle/ductile deformation along the Pacific-N. American plate interaction zone) and topography of the core mantle boundary and its connection with decade scale changes in earth rotation. The two major research elements covered here are: tectonic processes: a comprehensive and integrated research approach is emphasized, combining quantitative modeling and qualitative synthesis of diverse data types. The principal tasks include: (1) synthesis of geologic, tectonic, geophysical and geodetic data to develop kinematic models of block rotations and translations; (2) investigation of block rotation mechanisms within the brittle crust and complex motions occurring within the ductile lithosphere at depth along plate boundaries; (3) model thermal and mechanical characteristics of Baja/S. California to determine connection between rifting of Baja and origin of the Big Bend in the San Andreas; and (4) application of a strike-slip/thrust fault semi-analytic technique to study local motion of the Vandenberg fixed Very Long Base Interferometry (VLBI) base station. Topography of the core-mangle boundary: Shall be directly extracted from combined study of P-wave, PKP, and PcP seismic waves using the tomography technique. The completed P-wave study constrains density variations in the mantle but not undulations of the core-mantle interface, which shall be obtained from the PKP/PcP wave tomographic study. Changes in earth rotation shall be calculated from the effect of core topography on magnetically inferred, core surface flow fields and compared with observed changes.

W87-70364 **676-30-44**
Jet Propulsion Laboratory, Pasadena, Calif.
POLAR MOTION AND EARTH MODELS
J. O. Dickey 818-354-3235

The objective of this research is to obtain a better understanding of the physical processes which influence Earth rotation and polar motion. To obtain the goals, the investigation is divided into three separate tasks as follows: (1) Atmospheric Dynamics and the Excitation of Earth Orientation Changes: This task will involve comparison of publicly available estimates of the Earth orientation and the total atmospheric angular momentum with various meteorological data sets. A major goal of this task will be to verify the connection between changes in the equator to pole temperature gradient and changes in the length of day (the 50 day oscillations,

the seasonal variations, and the longer period changes correlated with the Southern Oscillation). The dynamical causes of any such relationship will be investigated. (2) Numerical Simulations of Atmospheric Angular Momentum Changes: The so-called 50 day oscillation in Earth rotation and in the atmosphere will be investigated by the use of a general circulation model of the atmosphere to provide insight into the atmospheric oscillation and its effect on Earth rotation. (3) Data Quality Enhancement and Verification: This task is intended to improve the quality and reliability of estimates of the excitation of changes in the Earth orientation. Estimates of the atmospheric excitation of Earth orientation changes from independent weather forecast centers will be analyzed to provide indications of the accuracy of these data. Surface pressure data will be usd to estimate the size of the water vapor accounting error; errors in the inverted barometer model of the ocean response will also be evaluated. Part of the atmospheric excitation of Earth orientation changes results from surface pressure changes; pressure-derived excitation estimates will be used to calculate changes in the low order spherical harmonics of the surface pressure for comparison with satellite tracking data.

W87-70365 **676-40-02**
Goddard Space Flight Center, Greenbelt, Md.
GEOPOTENTIAL FIELDS (MAGNETIC)
Robert A. Langel 301-344-6603

The major objectives of this RTOP are to develop more accurate and reliable models of the Earth's main magnetic field and its temporal variation, to study the physical processes in the core which are response for generation of that field, and to conduct studies preparatory to proposed missions. The approach includes both collection of all suitable data types and of the development of new analytic techniques. New observatory and repeat data are continually being added to our data set as they become available. During the past year a proper error analysis for the spline function representation of secular variation was developed. This will be utilized to project Magsat data to earlier epoch's as a priori for IGRF calculations. The formalism for error analysis was, and is being, refined and tested. Characteristics of the 1970 jerk were modeled and the results are being analyzed and prepared for publication. Data from the Air Force Defense Meteorological Satellite Program (DMSP) F-7 satellite were acquired from AFGL (Air Force Geophysics Lab) and are being utilized in new models.

W87-70366 **676-40-10**
Goddard Space Flight Center, Greenbelt, Md.
GRAVITY FIELD AND GEOID
Demos C. Christodoulidis 301-344-0883

The objectives are to: (1) develop a model of the Earth's gravity field based upon satellite tracking and altimetry and surface gravity data. The computed geopotential model, the interim field, will be used as the a priori model at the beginning of the Geopotential Research Mission (GRM); (2) develop state-of-the-art geodynamic software systems; perform research through the interpretation of geopotential signals; (3) conduct studies of a spaceborne gravity gradiometer system for Earth/planetary mapping of the gravity field; (4) evaluate flight concepts for a cryogenic gravity gradiometer using the Spartan configuration; and develop GRM local solution simulation using University of Texas gravity model and establish orbit constraints from matrix inversion techniques. Essential elements for the development of the interim field are: improvement methods of incorporating surface gravity data; development of techniques for extensive use of altimeter data, improvement of accuracy of models used on orbit determination; and optimization of the necessary software programs. The gradiometer studies are to focus on covariance analyses, simulation studies, hardware design, and engineering studies. The GRM simulation will use the University of Texas observational signal (180x180 field) and recover the gravity model and estimate its accuracy both in the local and global sense. Improved accuracy in features of the gravity field is expected to reduce the overall error of the geoid by about 50%. The gradiometer studies evaluate the gradiometer as a gravity mapping tool. Results from the GRM studies will consist of a global set of harmonic coefficients, local region gravity anomalies (1 deg x 1 deg), and orbital constraints on the satellites.

W87-70367 **676-59-10**
Goddard Space Flight Center, Greenbelt, Md.
GEOPOTENTIAL RESEARCH MISSION (GRM) STUDIES
T. Keating 301-344-8817
(676-40-10; 676-59-85)

The objective is to perform magnetic field data reduction studies and gravitational field mathematical modeling studies in support of the Geopotential Research Mission (GRM) as advanced Phase A studies. The effort will continue the on-going work to define the magnetic science products and the mathematical algorithms critical to the recovery of the gravitational field from the mission flight data, and investigate alternate designs. The studies will more rigorously define the science products and a possible method to obtain the gravitational field and identify spacecraft definition phase studies.

W87-70368 **676-59-10**
Jet Propulsion Laboratory, Pasadena, Calif.
GRAVITY FIELD MISSION STUDIES
D. Sonnabend 818-354-7593

The objective of this work is to continue the development of a technique for operating sensitive instruments, primarily gravity gradiometers, aboard the Space Transportation System (STS) vehicle (Shuttle), and other spacecraft. The technique provides either active vibration isolation or intermittent drag free operation of the payload instrument, with minimum impact on Shuttle systems or operations. The payload would be encased in a conducting shell, and set free inside a set of eddy current forcing coils. In the vibration isolation mode, the payload position is continuously fed back to the forcing coils, using arbitrary frequency shaping. In the semi drag free mode, the coils are operated only briefly, when collision with the coils is imminent. Previous studies have shown that normal Shuttle disturbances, including air drag, rotation, and crew motion can all be accommodated, and determined the special requirements associated with cryogenic payloads. Work is continuing to demonstrate single axis operation in the laboratory. Work on remote identification of the instrument parameters will be started in this period.

W87-70369 **676-59-31**
Jet Propulsion Laboratory, Pasadena, Calif.
GPS MEASUREMENT SYSTEM DEPLOYMENT FOR REGIONAL GEODESY IN THE CARIBBEAN
William G. Melbourne 818-354-5071

A new measurement system for centimeter geodesy will be developed and demonstrated in California and Mexico, and the Caribbean. The broad objective is to achieve baseline accuracies of 2 cm in the local vertical and 1 cm in each horizontal component over distances up to 2000 km in order to conduct key geodetic experiments in regions of tectonic interest. Among the problems to be addressed are: (1) the question of the direction and rate of relative motion between the North American and Caribbean plates, (2) the subduction of the Cocos plate beneath Central America, (3) the spreading rate across the Galapagos spreading center, (4) the spreading rates in the Gulf of California, (5) the nature of strain in southern California, and (6) uplift and deformation in the Long Valley caldera associated with magma injections. System development will build upon the successful demonstrations of the NASA SERIES and SERIES-X receiver systems and on a comparative evaluation of the TI4100 and the MACROMETER systems. A valuable inheritance of large scale estimation software from previous geodynamics and deep space navigation applications is being utilized. The SERIES-X and other available equipment, such as the TI 4100 and MACROMETER receivers, are used to conduct field experiments. Information gained from field experience and subsequent data analysis leads to improvements in field equipment and software algorithms. Initial measurements in California began in March/April 1985. Initial measurements in Mexico, across the Gulf of California, began in November 1985. Measurements in the

Caribbean are scheduled to begin June 1986. As more data acquisition terminals become available and system performance permits, additional baselines over longer distances will be included in the observing schedule.

W87-70370 **676-59-32**
Goddard Space Flight Center, Greenbelt, Md.
LASER RANGING DEVELOPMENT STUDY
J. J. Degnan 301-344-7714
(676-10-10; 692-20-10)

The long term goals of this RTOP are: (1) to develop automated millimeter accuracy satellite laser ranging (SLR) stations; and (2) to provide supporting analyses and technology tradeoff studies on a combined geodynamics/altimetry mission of the Geodynamics Laser Ranging System (GLRS) instrument on EOS (new element in FY-87). The technical strategy is to use dual wavelength, subnanosecond pulse laser transmitters and picosecond resolution streak camera technology to remove centimeter level range uncertainties caused by atmospheric refraction effects. Quadrant or imaging detectors will be incorporated into the system to permit totally automated star calibrations. Analytical studies of the limiting effects of speckle from existing targets such as LAGEOS on ranging accuracy will be carried out. Under this RTOP, earlier system studies of the (GLRS) will be updated to provide a preliminary assessment of the engineering impact of an additional, high duty cycle altimetry mission. Different altimetry missions vary in their data type (e.g., simple mean range vs. return waveforms for surface roughness investigations) and data volume which can impact transmitter energy and lifetime specifications and receiver design. The GLRS instrumental changes dictated by a combined geodynamics/altimetry mission will be investigated and also potential improvements to the instrument made possible by recent technological advances in the areas of laser pumping, high-speed photodetectors and spacecraft navigation.

W87-70371 **676-59-33**
Marshall Space Flight Center, Huntsville, Ala.
SUPERCONDUCTING GRAVITY GRADIOMETER
S. H. Morgan 205-544-0614

The objective of this RTOP is to develop a full vector, three-axis superconducting gravity gradiometer for space flight applications. The instrument will be designed to have a measurement sensitivity of .0001 ETVOS units in an orbital environment and exhibit a measurement time constant consistent with the current requirements of geodynamics research. The final functioning sensor unit will be constructed and tested in a manner consistent with a proto-flight approach to a possible scientific Shuttle flight.

W87-70372 **676-59-45**
Jet Propulsion Laboratory, Pasadena, Calif.
GPS POSITIONING OF A MARINE BUOY FOR PLATE MOTION STUDIES
T. H. Dixon 818-354-7535

This RTOP is intended primarily to perform a system analysis and demonstration of the use of GPS (Global Positioning System) receiver technology for determining the location of an ocean surface platform with respect to the GPS reference frame. The development of a system for measuring the location of benchmarks on the ocean floor with respect to an acoustic transmitter on the surface platform is being performed under other Geodynamics Program-sponsored research, by F. N. Spiess of Scripps Institution of Oceanography. The combined objective of these two RTOPS is to precisely tie ocean floor benchmarks to an earth centered reference frame. The GPS-based systems were developed for high precision, cost-effective geodetic measurements under the NASA Geodynamics Program. Current proof-of-concept receivers have demonstrated baseline measurements with accuracies of several cm. If this level of performance can be maintained in a system used at sea, it will be adequate for obtaining an absolute position for the surface element(s) of an acoustic sea floor benchmark system. Moreover, the instantaneous positioning data for the surface element of the array obtainable with GPS may enable the sound velocity variation in the upper 100 m of water to be constrained. Variability in this layer is expected to be a major error source. Some developments in the system design are required to use GPS technology for sea floor geodesy. These include antenna design, determining instantaneous positions of a wave-tossed platform and determining the orientation of that platform. Preliminary sea trials with the SERIES GPS receiver were used to gain engineering information. Data on platform acceleration and jerk, outages caused by obstructions and levels of RFI are being used to set GPS receiver and baseline solution software design parameters. The GPS receivers selected for this system will be tested initially on fixed baselines and eventually tested during sea trials of the acoustic positioning equipment.

W87-70373 **676-59-75**
Jet Propulsion Laboratory, Pasadena, Calif.
ADVANCED MAGNETOMETER
E. J. Smith 818-354-2248

The objective is to demonstrate that the helium magnetometer can be operated in a scalar mode which satisfies the requirements of the Geopotential Research Mission (GRM), the Magnetic Field Explorer (MFE), Tethered Satellite Systems (TSS) and similar future missions; to demonstrate that the helium magnetometer can be operated in a dual scalar and vector mode and fulfill the requirements of these missions; to evaluate a HE3 nuclear free-precession magnetometer which has the potential of providing extremely accurate magnetic field measurements with a very light-weight, low-power instrument. A team of both theoretical and magnetic field instrument experts was assembled and are working to attain the above objectives. The theoretical team, consisting of scientific experts involved in helium magnetometers since their inception has determined the theoretical limits of the scalar helium magnetometer; the instrumentation team has designed and fabricated instrumentation capable of attaining these limits.

W87-70374 **676-59-80**
Goddard Space Flight Center, Greenbelt, Md.
MAGNOLIA/MAGNETIC FIELD EXPLORER
G. Qusley, Sr. 301-344-8073

The objective is to conduct system definition studies for a Magnolia/Magnetic Field Explorer (MFE) mission. The studies will be based on the Magsat-A concept and will build on the studies completed by APL. The studies will produce the U.S. inputs for a definition phase spacecraft design with French CNES that could serve as the basis for a joint cooperative program. The French CNES is cooperating with NASA in this study activity which could lead to a joint mission on the Ariane launch vehicle.

Resource Observation Applied Research and Data Analysis

W87-70375 **677-21-05**
Goddard Space Flight Center, Greenbelt, Md.
FOREST BIOMASS
Forrest G. Hall 301-344-0974

The objective is to use remote sensing to better understand forest pattern and process at a regional scale in boreal ecosystems. In addition, existing remote sensing techniques, such as biomass estimation and species composition mapping, will be evaluated and where necessary, modified to meet the science requirements peculiar to boreal exosystems studies. The ecosystem landscape will be considered to be composed of a quiltwork of patches. Each patch will be characterized by its particular species compositional mix, and its above ground biomass. Landsat data will be used to identify the successional stage and biomass of each patch. By employing two or more Landsat observations, the between state patch transition probabilities can be estimated. These transition probabilities can then be used with stochastic theory to investigate the longer term dynamics of the ecosystem. The Landsat level studies rely on semi-empirical relations developed from canopy reflectance models and detailed field studies at the

tree and plot level using helicopter acquired Barnes Multimode Radiometer (MMR) data, LICOR measurements of canopy component spectral properties, and ground acquired biophysical properties data. The FY-87 activity will also focus on improving the understanding between the satellite measured reflectance and the compositional and biophysical properties of the forest stands.

W87-70376 **677-21-24**
Goddard Space Flight Center, Greenbelt, Md.
TERRESTRIAL ECOSYSTEMS
Darrel L. Williams 301-344-8860

The purpose of these studies is to assess a variety of biological and physical components of complex terrestria ecosystems such as forests using remotely sensed data. A variety of remote sensing tools will be used to address continental, regional, and local phenomena in order to derive information concerning the areal extent and condition of forests. Spaceborne, airborne, in situ, and laboratory spectral data as well as ground measurements were and are being acquired in order to develop the statistical techniques and procedures necessary to integrate Advanced Very High Resolution Radiometer (AVHRR)-Global Area Coverage (GAC) and Multispectral Band Scanners (MSS) digital data for continental resource assessment, and to assess the utility of fine spectral resolution aircraft measurements for detecting and quantifying forest stress due to acidic deposition. Expected Results: (1) a statistical and procedural approach for subcontinental/continental assessment of natural resources using multiresolution, multisensor digital imagery will be developed and tested; and the utility of high spectral resolution aircraft data for forest stress detection will be validated. In addition, laboratory experiments will provide insight into the physiological, morphological, and chemical factors which are responsible for altering plant reflectance characteristics in the field.

W87-70377 **677-21-25**
Jet Propulsion Laboratory, Pasadena, Calif.
TERRESTRIAL ECOSYSTEMS: SPECTRAL CHARACTERIZATION OF FOREST DECLINE DAMAGE
B. N. Rock 818-354-6229

This study will be a continuation of a program initiated in the summer of 1983. Objectives are as follows: to demonstrate the utility of using remote sensing techniques to detect, quantify, map and monitor forest decline symptoms in Vermont and New Hampshire, as well as the Federal Republic of Germany and Austria; to document biophysical parameter variables associated with forest decline damage, including canopy moisture levels, leaf anatomical variations; photosynthetic pigment concentrations, and leaf elemental contents; to experimentally alter these biophysical parameter variables while monitoring high spectral resolution reflectance and fluorescence data acquired both in the field and laboratory; and to collect spectral and biophysical data sets from controlled application experiments involving ozone, acidified mists, and heavy metals as applied to red spruce (Picea rubens) specimens, in coordination with U.S.D.A. Forest Service-supported investigators conducting such manipulative studies. The study was designed so that the spectral data can be coupled to detailed laboratory analysis to allow quantitative and qualitative spectral characterization of ecosystem variables. Conduct field and laboratory investigations in support of airborne and spaceborne remote sensing data acquisition for selected terrestrial ecosystems. This RTOP is divided into three separate Tasks as Follows: (1) Conduct field studies consisting of habitat assessment, moisture stress determination, and in situ spectral data acquisition (VIRIS and laser) from selected acid rain damage sites. Laboratory studies will include anatomical and physiological assessment of susceptible tree species, both in situ and under controlled conditions (greenhouse/open top chambers). (2) Conduct manipulative experiments in which certain leaf biophysical parameters are artificially altered and high resolution spectral data are acquired and assessed. (3) Collect and analyze AIS II/AVIRIS/TMS data acquired in the 0.4 to 2.4 m region in order to evaluate their utility for vegetation remote sensing.

W87-70378 **677-21-31**
Ames Research Center, Moffett Field, Calif.
FOREST EVAPOTRANSPIRATION AND PRODUCTION
D. L. Peterson 415-694-5899

The objectives are to determine evapotranspiration (ET) and net primary productivity (NPP) for a large regional coniferous forest, to test extrapolation limits of ecosystem process models of ET and NPP, and to test theories necessary for efficient partitioning and aggregation of a forested landscape to support regional level estimations. The strategy is to implement an appropriately modified version of DAYTRANS/PSN, an existing physiologically based model simulating ET and NPP at the conifer stand level, for initially a small watershed and later a 2600 km2 basin in Western Montana. Variables relating to key processes controlling energy, carbon and water exchange will be derived from remote sensing, digital terrain, in-place measurement, and soil data. The variables, to be interrelated in a geographic information system, are: (1) site physical properties (slope, aspect, elevation, soil) obtained by automated partitioning of the terrain into hydrologically meaningful landscape units; (2) surface meteorological conditions including radiation balances, canopy/air temperature, humidity, precipitation; and (3) vegetation characteristics, leaf area index and total biomass. Estimates of ET and NPP will be validated using independent hydrologic yield measurements and productivity estimates from ground sampling.

W87-70379 **677-21-32**
Goddard Space Flight Center, Greenbelt, Md.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-344-7122
(199-30-99)

The objective is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30m, 80m, 1km, 4km and 15km for selected local areas (30 and 80m), regional test sites (1km), continental test areas (4 and 8km), and the entire planet (15km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity, land cover mapping, deforestation, insect and disease upsurges, and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, the carbon cycle, and the hydrological cycle. Expected results are: (1) the understanding of large-scale vegetation response and its relationship to atmospheric and climatic phenomena; (2) estimates of grassland biomass production across entire continental ecological zones; (3) global estimates by continent of land cover types and how these vary with time; (4) improved documentation of tropical deforestation, and estimates of forest spatial extent for selected tropical and boreal forests; (5) understanding the coupling of directional reflectance and atmospheric effects, (6) developing the computer-related software to process large volumes of course resolution satellite data and handle multilevel satellite data from the same target; and (7) determination of desert boundaries and desert spatial extent.

W87-70380 **677-21-33**
National Space Technology Labs., Bay Saint Louis, Miss.
INTERACTIONS OF ENVIRONMENT AND VEGETATION COMPOSITION, STRUCTURE, AND FUNCTION ON A MAJOR TROPICAL ECOCLINE
Diana Lieberman 601-688-1912

A major tropical ecosystem gradient on the Atlantic slope of Costa Rica's Cordillera Central joins La Selva near sea level with Volcan Barba at 2900 m elevation 35 km to the south. It is proposed to investigate patterns and interactions of environmental parameters with floristic, structural and functional properties of the vegetation over this gradient. The project involves field studies of environment and vegetation; remote sensing of forest structure (laser profiler), thermal and evapotranspiration patterns (TIMS), and spectral characteristics especially related to plant vigor (Central Atmospheric Monitoring System (CAMS and AVIRIS); and a

large-scale factorial field experiment designed to generate a graded vigor response for spectroradiometric analysis. Spectral signatures indicative of vigor will be determined, and the results applied to natural vegetation using CAMS and Airborne Visible and Infrared Imaging Spectrometer (AVIRIS); predictions from AVIRIS data analysis will be tested with forest growth studies. Information that will be acquired will have profound implications for modelling of terrestrial ecosystem processes.

W87-70381 **677-21-35**
Ames Research Center, Moffett Field, Calif.
BIOGEOCHEMICAL CYCLING IN TERRESTRIAL ECOSYSTEMS
D. L. Peterson 415-694-5899

The objective is to develop and use theoretical models and empirical studies to derive biochemical information from leaf and canopy spectra; to relate these measurements to ecosystem productivity and nutrient cycling for temperate and tropical gradients; to incorporate these findings into developing ecosystem process models; to determine the biochemical/biophysical response to airborne pollutants in select ecosystems; and, to relate flux measurements of methane and other trace gases from arctic tundra ecosystems and model the atmospheric interactions. The approach will be: to develop and test deconvolution-based and biophysical models of leaf spectral characteristics accounting for biochemical properties; apply these techniques to canopy models to understand the canopy chemistry in empirical remote sensing studies using visible to short-wave spectral sensors (e.g., Airborne Visible and Infrared Imaging Spectrometer (AVIRIS)); design, conduct and compare gradient studies of ecosystem nutrient cycling using established methods and incorporate/test in the continuing model development; combine water-carbon-nutrient processes and interactions in ecosystem models and test for generality; spectral, chemical and anatomical analyses will be conducted on fumigated and naturally occurring pollutant damaged plants and ecosystems; measure methane and other trace gases from sample sites optimally selected from remote sensing analyses of tundra ecosystems and extrapolate to large scale using multistage methods and input to atmospheric model.

W87-70382 **677-21-36**
Jet Propulsion Laboratory, Pasadena, Calif.
SATELLITE MEASUREMENT OF LAND SURFACE PARAMETERS FOR CLIMATE STUDIES
E. G. Njoku 818-354-5607

Research is performed to evaluate the potential of three different satellite sensors for measuring parameters of use in land surface climatology studies. The sensors are the Scanning Multichannel Microwave Radiometer (SMMR), the High Resolution Infra-Red Sounder/Microwave Sounding Unit (HIRS/MSU), and the Advanced Very High Resolution Radiometer (AVHRR). Data from these instruments can be used to provide information on surface soil moisture, temperature, and vegetation cover, all of which are key parameters in models of energy exchange at the land-atmosphere boundary. Time-series of derived data from these sensors will be compared for a complete seasonal cycle over the same geographic locations, primarily the African Sahel, in order to quantify the relationships between sensor measurements and surface features. Results will lead to better use of satellite data in understanding and monitoring climate change, and will form part of the recently-initiated International Satellite Land-Surface Climatology Project (ISLSCP).

W87-70383 **677-21-40**
Goddard Space Flight Center, Greenbelt, Md.
FOREST DYNAMICS
James A. Smith 301-344-7282

The Earth System Science Committee (ESSC) has recognized the tremendous increased capability offered by the forthcoming Earth Observation Satellites (EOS) observing platforms to obtain measurements at local, regional, continental and global scales for the hydrosphere, geosphere, biosphere, and atmosphere components of the total earth systems. The existing large-scale oceanographic and climatological modeling experience available in the scientific community today bodes well for the utilization of these increased satellite measurement capabilities. Presently, however, the biological component of the global puzzle appears to enter mostly into local calculations of rate factors or energy component/boundary condition constraints. Clearly, these are important coupling conditions required for a total understanding of global processes. However, the fundamental question of why particular life forms occupy their present spatial/temporal niche demands a stronger biological modeling role for terrestrial biomes at global scales. The objective of this study is to initiate, in conjunction with the scientific community at-large, forest dynamic modeling studies appropriate for projecting the spatial successional stages of an important component of the terrestrial surface that is tightly coupled to large-scale environmental changes. Investigate and encourage the development of large scale pattern and process forest dynamic modeling techniques appropriate for predicting forest landscape patterns and trends. Conduct workshops and encourage exchange of of local and regional observations necessary for calibration and validation of these models.

W87-70384 **677-22-28**
Goddard Space Flight Center, Greenbelt, Md.
WATER RESOURCES CYCLING (ISLSCP)
R. J. Gurney 301-344-5480

The objective is to determine the capability of extracting quantitative estimates of land surface parameters from satellite radiance observations. These parameters include components of the surface energy balance such as albedo, latent and sensible heat fluxes, surface temperature and insolation. The approach was to: analyze existing satellite data, e.g., NOAA/Advanced Very High Resolution Radiometers (AVHRR) Nimbus/Scanning Multichannel Microwave Radiometer (SMMR) and Landsat/Mulitspectral Band Scanner (MSS) for land surface parameters, and conduct coordinated field experiments in which satellite, aircraft and surface determinations of land parameters are intercompared. These efforts will be part of the International Satellite Land Surface Climatology Project (ISLSCP). The expected results: (1) Data from the Hydrologic and Atmospheric Pilot Experiment (HAPEX) will be analyzed to estimate regional evaporation during The experiment; (2) The First ISLSCP Field Experiment (FIFE) will be conducted in Kansas; and (3) a five year set of data from Nimbus-7 SMMR will be used to calibrate a soil moisture mass balance model over the South-Western Great Plains of the U.S.

W87-70385 **677-24-01**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING SCIENCE PROGRAM
Donald W. Deering 301-344-9186

The Remote Sensing Science Program is conducted to improve the general scientific understanding of the energy emitted or reflected from an earth surface target, through the intervening atmosphere as measured by a remote sensing system. It is designed to provide a foundation upon which new, more advanced satellite and aircraft remote sensing instruments and interpretive techniques can be developed. At its heart is developing and understanding of the physical processes whereby radiant energy is emitted or reflected from earth land surface targets and the relationships of the measurable radiant energy to important biophysical attributes and processes. The Goddard Space Flight Center (GSFC) responsibility includes the project management and several of the fundamental research tasks. Seeking new research and evaluating proposals; monitoring continuing studies; and conducting workshops, progress review meetings and conference technical sessions, as well as performing the necessary procurements activities will be continued in a manner similar to previous years. Continued advancement of the state-of-the-art of theoretical models that predict radiant energy response from earth surfaces and improvement in empirical characterizations that lead to the formulation of mathematical process models, which relate reflected and emitted radiation to scene attributes, are expected from this effort.

W87-70386 **677-41-29**
Jet Propulsion Laboratory, Pasadena, Calif.
MULTISPECTRAL ANALYSIS OF ULTRAMAFIC TERRAINS
M. Abrams 818-354-0937
(677-80-23)

The objective of this project is to examine problems of lithological discrimination and structural mapping of ophiolites using visible, near-infrared, and thermal images and field measurements. The work will focus on determining the potential contributions of remote sensing techniques to the study of basic geologic questions related to the formation and emplacement of ophiolites. Ophiolites are characteristic assemblages of ultramafic and mafic rocks interpreted to be sections of the Earth's oceanic crust. They are generally exposed at the margins of continental areas as the result of tectonic emplacement during plate collisions. Important problems relate to the distribution and 3-dimensional mapping of dunite and harzburgite in the basal peridotite section to constrain models of mid-ocean magma chamber geometry; recognition and mapping of serpentinization bears on tectonic emplacement mechanisms and earlier sea floor hydrothermal alteration. Test areas and researchers with whom we are actively cooperating are the Samail ophiolite (Oman) with Dr. Rothery, Open University, London, and Dr. Stakes, University of South Carolina; the Bay of Islands ophiolite (Newfoundland) with Dr. Karson, Duke University. In each of these areas, Thematic mapper (TM), Thermal Infrared Multispectral Scanner (TIMS) data were acquired. During Fy-87 we will perform the following tasks: (1) continued analysis of TM data, field spectral data, and laboratory analysis of field samples for the Samail ophiolite; (2) analyses of TM and TIMS data for the Bay of Islands Ophiolite; (3) completion and publication of laboratory spectrometric study of serpentinization in 0.4 to 12 micron region; and (4) field work as required to verify image interpretations, collect samples for laboratory analysis. Computer processing of the data will be accomplished at the Geology group's computer facility; analyses and interpretations will be done jointly by the PI and cooperating researchers from outside universities.

W87-70387 **677-42-09**
Jet Propulsion Laboratory, Pasadena, Calif.
ARID LANDS GEOBOTANY
B. N. Rock 818-354-6229

The overall objective of the proposed research is to acquire and evaluate remote sensing measurements obtained at visible, reflective and thermal infrared, and microwave wavelengths to determine the relating contribution of vegetation to multispectral surface data acquired by airborne and spaceborne sensors for arid and semi-arid settings. In FY-87 further the accuracy of modeling techniques currently under development to detect and quantify the spectral characteristics of geologic and edaphic materials covered by less than 50% vegetation will be tested. Using ground and aircraft high spectral resolution Visible Near Infrared (VNIR)/Shortwave Infrared (SWIR) data to characterize the vegetation and soil contribution for selected arid land plant communities at various times of the year, attempts will be made to use both spectral features and vegetation indices to isolate the vegetation component from remotely sensed data sets. The relationship between weathered fan surfaces of different ages and condition, community composition, and biomass will be assessed utilizing both field data and Airborne Visible and Infrared Imaging Spectrometer (AVIRIS). Key elements continue to assess vegetation type and condition for dominant arid land plant communities in Owens Valley, CA. Gather additional in situ spectral data sets (at VNIR, SWIR, and microwave wavelength) for representative vegetation and soil types. Assess the use of absorption features associated with cellulosic materials as well as vegetation indices to detect and quantify variables in vegetation type and condition, as well as substrate variables associated with alluvial fans of different ages, using new burn sites within Owens Valley to test accuracy of results. Acquire aircraft data sets (Thematic Mapper Simulation (TMS) and AVIRIS) in the VNIR and SWIR wavelengths from old as well as new sites. Continue anatomical/physiological assessment of selected species to determine biophysical parameters affecting spectral properties of arid land vegetation.

W87-70388 **677-43-21**
Jet Propulsion Laboratory, Pasadena, Calif.
TECTONICS OF WESTERN BASIN AND RANGE
R. Blom 818-354-4681

The objectives of this study are to develop and evaluate the capability of mapping detachment faults from remote sensing data, apply this first in an accessible region which is the subject of much study at present, and extend the capability for efficiently mapping such structures elsewhere. Recent study of detachment faults in the southwestern U.S. reveal major Tertiary crustal extension, in part on reactivated Mesozoic thrusts. This type of extensional tectonics may be a previously unrecognized major phase of continental margin tectonics. These faults expose basement deformed in a ductile manner in low-angle fault contact with upper plate rocks deformed in a brittle manner. A consortium, similar to COCORP, of geological investigators called CALCRUST was formed and funded by National Science Foundation (NSF) at $1.4M to begin seismic study of selected detachment faults. It is likely that many detachment faults, even in the southwest, have yet to be recognized. Despite the tremendous amount of work done in the southwest, the major tectonic problems remain elusive. This remote sensing study is thus a logical and timely complement to the CALCRUST study. The essence of the study is acquisition and study of Landsat Thematic Mapper (TM), Seasat, SIR-A-B, and Large Format Camera (LFC) initially for CALCRUST targets and then to surrounding areas. The spectral and morphotectonic characteristics of detachment faults discernible in the images will be documented, beginning with known faults, moving to faults in crystalline rocks, and then integrating a regional picture. Research emphasis is on fault detection, determination of structural levels involved, and regional synthesis. Cooperation with University of California at Santa Barbara (UCSB) and CALCRUST investigators is planned. The goal is development of a remote mapping strategy for these features.

W87-70389 **677-43-22**
Jet Propulsion Laboratory, Pasadena, Calif.
LANDFORMS IN POLAR REGIONS
J. P. Ford 818-354-6735

This study will investigate spaceborne radar and other remotely sensed images for mapping and interpretation of glacial and periglacial landforms in the arctic environment. Of most interest are localities with geomorphic features that relate to the changing Quaternary climate. Such features include moraines of drumlins, abandoned river channels, strandlines and terraces, dunes and various types of low-relief features associated with permafrost terrain. Moraines and drumlins will be mapped and analyzed with respect to their morphology, orientation, extent and spatial relations. Interpretation of these data is expected to provide evidence of glacial movements or mark the limits of glacial covers of different ages. Abandoned river channels associated with terraces or adjacent strandlines can provide scientific information concerning glacial advances and retreats. The shape, orientation and distribution of dunes denote dominant wind directions. The distribution and character of permafrost-related periglacial features provide important climatic and environmental information. Seasat Synthetic Aperture Radar (SAR) images will be used as a primary data source. Study sites will be selected from existing Seasat SAR coverage of Alaska and the Northwest Territories of Canada, depending on availability and quality of the images. Some examples of potential study sites include: (1) hummocky topography east of the MacKenzie River produced by buried glacial ice, hillocks and ponds represent dunes that have been glacially overridden; (2) permafrost features on the North Slope, Alaska; (3) abandoned river courses and terraces along the Colville River; and (4) active and stabilized dune fields in the northwest interior basin, Alaska.

W87-70390 **677-43-23**
Goddard Space Flight Center, Greenbelt, Md.
CONTINENTAL ACCRETION
Charles C. Schnetzler 301-344-5213

The primary purpose of this work is to improve the understanding of the nature and extent of continental accretion as a process

in continental crust formation. The secondary objective is to develop remote sensing procedures, techniques, and instruments which can be used to better understand this process. This RTOP brings a broad spectrum of disciplines to the study of terrane accretion. Initially, classical remote sensing, variable-baseline topographic slope analysis, geobotanical studies, and magnetic anomaly modeling will be used. Other data types such as gravity, may be added. Ground based (field), aircraft and satellite data will be used. Initial study sites will be along the west-coast of North America (Oregon and British Columbia), eastern Canada, and northeastern United States; as work progresses the work will probably focus on a more limited number of sites.

W87-70391 **677-43-24**
Goddard Space Flight Center, Greenbelt, Md.
TOPOGRAPHIC PROFILE ANALYSIS
James B. Garvin 301-344-6565

This new project will quantitatively analyze high-resolution topographic profiles obtained from aircraft laser altimetry, as well as from oceanographic radar altimetry data overland (e.g., GEOS, Seasat, and Geosat) in order to explore and define fundamental wavelengths associated with dynamic surface processes such as volcanism, tectonism, impact, and erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a Goddard space Flight Center (GSFC) aircraft laser altimeter (10 m footprints, approx. 1 m vertical precision) and, will, for the first time, permit exploration of the spectral topographic (and slope) properties of erosion, catastrophic phenomena, and geodynamic processes (crustal) warping etc.). Data obtained from the GSFC aircraft laser altimeter (developed by J. Bufton of Code 723.3 and colleagues) for selected targets including youthful volcanics (SP flow), eroded impact features (Meteor and New Quebec craters), major Shield structures (Grenville Front), and suspect terrains (Klamath Mtns.) will result in high resolution (spatial and vertical) topographic profiles which will subsequently be analyzed by means of classic spectral analysis and interpreted. Dominant wavelengths associated with specific terrains and processes will thus be defined; such data can then be used as boundary conditions in mechanical models for certain landforms. In order to explore longer wavelength properties of crustal structure associated with major tectonic belts on the Earth, GEOS and Seasat altimetry will be retracked over land targets in Western Australia and the Caucasus Mountains (and nearby Aral Sea).

W87-70392 **677-43-25**
Jet Propulsion Laboratory, Pasadena, Calif.
REMOTE SENSING OF VOLCANIC FEATURES
D. C. Pieri 818-354-6299
(677-80-23)

Under this RTOP we hope to acquire and analyze multispectral data on active and emplaced volcanic features with attention to the thermal infrared (e.g., Thermal Infrared Multispectral Scanner (TIMS), Airborne Imaging Spectrometer (AIS), Inframetrics 525). In particular, we will investigate the relationship between remote data (e.g., TIMS, AIS, Zeiss, radar) and the spectral-physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). Of high interest for FY-87 will be a morphology/process-model/spectral comparison of Hawaiian and Italian volcanic shields, as well as thermal analysis of high-risk calderas in California and Italy. We will draw on data and techniques already acquired and proven by the JPL Geology Group, plus ongoing work in theoretical and applied volcanology by the author and other JPL co-workers. Ultimately we hope to utilize these techniques from earth orbit to address basic volcanological problems, as well as global habitability and societal risk concerns, particularly with regard to high-energy explosive volcanic events.

W87-70393 **677-45-03**
Goddard Space Flight Center, Greenbelt, Md.
SOURCES OF MAGNETIC ANOMALY FIELD
Patrick T. Taylor 301-344-5412

We will study the long-wavelength crustal magnetic anomalies observed at satellite altitude. By fully utilizing the Magsat data set we expect to determine the source geometry, including crustal thickness, and general petrologic nature of the geologic features producing these anomalies. A comprehensive approach will be conducted to describe the geometry and petrologic character of the source of the crustal magnetic anomalies observed at satellite altitude. Magsat anomaly amplitudes will be used to determine crustal thickness in tectonically significant regions such as large rift zones and Atlantic-type continental margins. Petrologic models will be used to establish possible source rock types and mode of magnetization. The state of magnetic mineralogy will be inferred from rock composition, mineralogy, grain size, redox conditions, pressure and temperature. Previous work has suggested a complex model including both viscous and induced magnetization. Magsat vector (x, y, and z) fields will be used to outline the surface expression of anomalous source body. Previously, vector fields were used to demonstrate the presence of remanent magnetization. Now they will be used to describe the shape of the source region and locate the center of magnetization. To further enhance the description of the source body, we plan to use the continuation downward algorithms. This RTOP represents an integrated and combined approach to the geologic interpretation of Magsat data. This effort will draw heavily upon the work and computer programming conducted in the previous years RTOPs.

W87-70394 **677-45-06**
Goddard Space Flight Center, Greenbelt, Md.
DETERMINATION AND INVERSION OF CRUSTAL MAGNETIC FIELDS
Robert A. Langel 301-344-6603

The basic objective of the program is to isolate crustal fields from the core and external fields and to invert the isolated crustal fields to an equivalent crustal magnetization. Products include filtered data, average anomaly maps, reduced (to common altitude, to the pole) anomaly maps and magnetization maps. The word map includes both the digital data and the actual map. The consequences of failure to isolate the crustal fields perfectly are investigated. The approach consists of (1) the development of suitable data selection criteria; (2) the development and testing of appropriate filters; (3) evaluating models of the core field; (4) estimating or modeling external fields and correcting the data suitably; (5) theoretical analysis of inversion techniques and implementation of useful results; (6) devising forward models to simulate expected anomaly behavior for evaluation of both the validity of solution of crustal fields and consequences of errors in isolation.

W87-70395 **677-46-02**
Jet Propulsion Laboratory, Pasadena, Calif.
NEW TECHNIQUES FOR QUANTITATIVE ANALYSIS OF SAR IMAGES
D. L. Evans 818-354-2418
(677-41-07; 677-41-03)

The advent of multiparameter Spaceborne Imaging Radars (SIR) will make it possible to derive quantitative signatures for geologic surfaces that can be used for mapping rock types and modelling surface processes. Sensors such as SIR-B with its multiincidence angle capability and the NASA/JPL quadpolarization L-, and C-band airborne Synthetic Aperture Radar (SAR) provide prototypical data set for future sensors such as SIR-C, SIR-D and Eos SAR, thereby making it possible to develop optimum data analysis tools at an early stage. The main objectives of this RTOP are: (1) to develop a physical basis for the use of multiparameter radar data in solving geologic problems; (2) to develop methodologies for optimizing radar parameters for geologic investigations; (3) to develop advanced data analysis tools for handling multiparameter signatures of geologic surfaces. The approach will be to combine field and laboratory measurements with theoretical models and radar backscatter information derived from calibrated multiparameter SAR images. We will develop techniques for the measurement of geologic characteristics for input to scattering models so that the models can be tested and modified. In addition, we will establish empirical relationships between radar backscatter and

measureable geologic parameters such as roughness, geometry, porosity, moisture content, and subsurface structure. The value of different radar parameters such as polarization and incidence angle will also be evaluated. We will also develop analytical tools for the extraction of information from multiparameter SAR images. These techniques will include using polarization signatures to examine details of surface and volume scattering, and deriving polarization combinations that maximize surface or volume returns. This proposal covers the continuation of a basic research effort at JPL involving the implementation of new techniques for analyzing SAR images. It represents the efforts of three researchers in the Radar Sciences Group and one researcher in the Radar Systems Group at JPL.

W87-70396 **677-80-19**
Jet Propulsion Laboratory, Pasadena, Calif.
GEOLOGY PROGRAM SUPPORT
C. Elachi 818-354-5673

The objective of this RTOP is to provide support to the Land Processes Branch, Earth Science and Applications Division, by the assignment of JPL detailees to NASA Headquarters. The primary duties of the detailees will be to provide assistance in the development and monitoring of the NASA geology programs.

W87-70397 **677-80-22**
Jet Propulsion Laboratory, Pasadena, Calif.
IMAGE PROCESSING CAPABILITY UPGRADE
S. D. Schultz 818-354-8009

The objective of this work is to establish an interactive image processing capability within building 183 to satisfy the image analysis needs of the geology group. The current operational system consists of the group's VAX 11/750 computer, 1.2 gigabytes of disk storage, 1 tri-density high speed tape drive, 1 medium density tape drive, an interactive color image processing workstation, a Sun workstation configured as an Airborne Imaging Spectrometer (AIS) data analysis workstation, as well as the TAE-VIGAR2 and DIPIX image analysis software package. Both the VAX 11/750 and the Sun workstation are on a network which also includes the AVIRIS VAX and AVIRIS Sun workstation. In the foreseeable future additional hardware will be required including disk storage, a film playback device, a high resolution scanner for map input, and an additional color display workstation. Upgrades to the system that are required this year include a second tri-density high speed tape drive, an upgrade to the DIPIX display device, additional air conditioning and maintenance services. The approach to be taken in this project consists of three main tasks. First the acquisition, integration and writing of applications software. This includes the continuing work on the conversion program between the TAE-VICAR2 data format and the DIPIX data format as well as integration of the LOWTRAN atmospheric modeling program into the TAE-VICAR2 software package. Second, the operational expenses of the computer system including additional air conditioning and maintenance services. Finally the acquisition and integration of computer hardware including a second tri-density tape drive and an upgrade to the display processor.

W87-70398 **677-80-80**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAM DEVELOPMENT (GSFC)
Vincent V. Salomonson 301-344-6481
(677-24-01; 677-22-27; 676-59-32)

The overall purpose of this collection of investigations is to advance some high potential or key areas of effort in such a way as to amplify or strengthen the total Land Processes Program at Goddard Space Flight Center (GSFC) and in NASA. The areas to be amplified or strengthened include: (1) the use of the aperture synthesis concept for long wavelength, passive microwave radiometry; (2) the application of the Pilot Land Data System concept to near-term needs of key scientific multi-investigator areas of effort; (3) the planning and formulation of a strong hydrological research program; (4) improvement of laser altimeter transmitters, receiver electronics and associated aircraft platform dynamics; (5) implementation of the Advanced Solid-State Array Spectrometer for Earth Observatory Satellite (EOS) simulation purposes. The principal results expected in the next year are: airborne testing of the L-band aperture synthesis concept; last-mile connections of data bases for the International Satellite Land-Surface Climatology Project (ISLSCP) and sedimentary basin project; procurement of parts and modifications of Nd:Yag laser system with 1-5 nanosecond pulses with high peak power; and the installation of the ASAs on NASA's DC-8 with support equipment to process high volumes of data.

W87-70399 **677-92-22**
Goddard Space Flight Center, Greenbelt, Md.
INTERDISCIPLINARY STUDIES LAND CLIMATOLOGY - RETROSPECTIVE STUDIES
R. Price 301-344-5411

The Retrospective Studies portion of the Interdisciplinary Studies Land Climatology program is conducted to determine if changes in regional scale climate due to natural or anthropogenic changes in land use/land cover can be detected in the historical satellite data record. Several years worth of Advanced Very High Resolution Radiometer (AVHRR) and Thematic Mapper/ Multispectral Scanner Subsystem for several study sites in the U.S. and Africa (central Great Plains, Sonoran Desert, Sahel Region, Botswana), where changes in land and use/land cover changes are expected and could already be documented, will be examined and compared to historical meteorological records in an attempt to identify correlations. Relationships between meteorological parameters, such as precipitations and evapotranspiration, and land surface parameters, such as vegetation cover and land structure change, are expected.

W87-70400 **677-92-23**
Goddard Space Flight Center, Greenbelt, Md.
INTERDISCIPLINARY STUDIES LAND CLIMATOLOGY - MEASUREMENTS TECHNIQUES
R. Price 301-344-5411

Measurements Techniques portion of the Interdisciplinary Studies Land Climatology program is conducted to validate/ calibrate methods for measuring/analyzing either changes in the regional or continental scale climate, or natural or anthropogenic changes in land use/land cover, in order to determine the effect of one on the other. Field data collection, satellite data analysis, and modeling methods for several different meteorological/land surface parameters such as evapotranspiration, energy balance, surface moisture, and soil boundaries will be developed, evaluated, and intercompared. Several specific models will be developed, such as infrared models of soil moisture and sub-grid scale models of vegetation variations. Satellite data calibration techniques for Advanced Very High Resolution Radiometer (AVHRR) data will be developed. Methods for measuring meteorological and land parameters such as evapotranspiration, energy balance, moisture, and soil boundaries will be developed.

W87-70401 **677-92-24**
Goddard Space Flight Center, Greenbelt, Md.
INTERDISCIPLINARY STUDIES LAND CLIMATOLOGY - GLOBAL SIMULATIONS
R. Price 301-344-5411

The Global Simulations portion of the Interdisciplinary Studies Land Climatology program is conducted to develop models of the atmosphere which contain the influences of land surface status and dynamics. General Circulation Models (GCM) of the atmosphere will be expanded to include initializations and parameterizations which depend upon vegetation and water features of the land surface. GCMs containing the hydrologic cycle, and vegetation canopy/vegetation index, and biospheric interactions are expected.

Mars Observer

W87-70402 **838-59-03**
Jet Propulsion Laboratory, Pasadena, Calif.
DEVELOPMENT OF THE PRESSURE MODULATOR INFRARED RADIOMETER
D. J. McCleese 818-354-2317

The objective of this task is the development of advanced infrared instrumentation for NASA's program of planetary exploration from spacecraft. The emphasis is on the following atmospheric science goals: (1) determine the thermal structure and its spatial and temporal variability in the terrestrial and outer planets, (2) map the abundance and vertical, lateral and temporal variability of key atmospheric species, (3) measure, by direct and indirect means, atmospheric motion, and (4) determine the physical properties of clouds and aerosols. The investigation of surface phenomena is also of fundamental importance in the rational development of infrared instrumentation. In particular our objective is the application of infrared remote sensing to the determination of surface thermal balance, thermal inertia measurements and the mapping of surface morphology. The approach will be to develop in the laboratory the critical hardware for an advanced infrared sounder. During FY-87 this task focuses on the definition and development of the Pressure Modulator Infrared Radiometer (PMIRR) for the proposed Cassini Saturn orbiter/Titan Flyby mission. The PMIRR employs pressure modulation and narrowband filter radiometry in both limb and nadir sounding modes, to obtain simultaneous vertical profiles of temperature, pressure, selected chemical species and aerosols in the atmospheres of both Saturn and Titan. The PMIRR instrument concept builds upon the PMIRR instrument selected for Mars Observer, and a substantial heritage of flight-proven hardware used on Earth and Venus orbiting spacecraft.

W87-70403 **838-59-04**
Jet Propulsion Laboratory, Pasadena, Calif.
DEVELOPMENT OF DUAL FREQUENCY AND MULTISPECTRAL RADAR MAPPER/SOUNDER
C. Elachi 818-354-5673

The objective of this activity is to define, develop and test the critical elements of a dual frequency (1.2 GHz, 37 GHz) altimeter/radiometer applicable for Mars Geoscience/Climatology Orbiter (MGCO), and a multispectral (1.2 GHz and 15 GHz) radar mapper/sounder applicable to a Titan Orbiter. The emphasis will be on developing the basic radar sensor elements which could be applied to multiple missions, in addition to MGCO and Titan Orbiter, such as Lunar Geoscience Observer (LGO) and other observer or Mariner Mark 2 missions. The approach is to develop a modular architecture where a large number of the modules are common for both the MGCO and Titan radar sensors. These modules will be defined, developed and tested in the laboratory. In addition, some modules which are unique and critical to each sensor, and require technological development, will also be developed.

W87-70404 **838-59-06**
Jet Propulsion Laboratory, Pasadena, Calif.
IR MAPPER
J. B. Wellman 818-354-6638

The major objective covered in this RTOP is the engineering required for the continuing design definition of the Visible and Infrared Mapping Spectrometer (VIMS). VIMS is a set of facility class instruments for a suite of planetary exploration missions. These instruments will provide the high spectral resolution image information necessary for the basic understanding of the surface composition, surface geology, as well as the ongoing geological/meteorological processes for selected planetary missions. The approach used to perform the preliminary definition of an instrument for a particular mission makes use of two teams. The science team is a group of recognized planetary scientists from various laboratories and universities. The purpose of the science team is to define the science goals and specify the instrument measurement requirements required to meet those goals. The design team is composed of the engineers that translate the scientific measurement requirements into system design requirements. The design team performs design analysis, technology readiness assessments, and engineering evaluations and tradeoff studies as necessary, to demonstrate the instrument feasibility, within acceptable cost and schedule risks.

W87-70405 **838-59-50**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY/GAMMA-RAY FACILITY PROGRAM
J. I. Trombka 301-344-5941

The X-Ray and Gamma-Ray Remote-Sensing (XGRS) Spectrometer Facility is being proposed for use on a number of planetary missions. These missions are part of the program developed under the Solar System Exploration Committee (SSEC) Study. Such remote systems are being readied for the Mars Observer, the Lunar Geochemical Orbiter, and the Near Earth Crossing Asteroid Rendezvous missions. The XGRS Spectrometer has been selected by the Director of the Solar System Exploration Division to be developed as a facility instrument to be flown where appropriate in the Observer and Mariner Mark 2 families of missions. An Instrument Definition Science Team (IDST) will be established and have the responsibility for guiding the development activity. A different Flight Investigation (FIT) will be selected for each mission based on proposals submitted in response to announcements of opportunity. FIT's will have the responsibility for developing the calibrations and mission profile and for planning, operations, and data analysis. The XGRS facility program will be managed by the Laboratory for Astronomy and Solar Physics of the Goddard Space Flight Center.

W87-70406 **838-59-80**
Jet Propulsion Laboratory, Pasadena, Calif.
DESIGN DEFINITION FOR A PLANETARY THERMAL INFRARED MULTISPECTRAL SCANNER (PTIMS)
D. C. Pieri 818-354-6299

We have two main objectives during the one-year performance period of this proposal: (1) to produce a conceptual design for a multispectral thermal infrared imaging system for a Planetary Observer class mission which will allow: (a) the distinguishing of primary geological units on the basis of silica/alumina mineralogy as a minimum, and (b) the determination of the structure and probable source lithology of weathering products e.g., regolith (to accomplish this task we will define primary science requirements which the instrument design concept must meet in the context of Observer class power, weight, and data rate constraints); (2) to produce a multi-year follow-on proposal for the development of a final design and the associated technology, and to begin fabrication and testing of specific breadboard components in preparation for an eventual flight instrument proposal, probably for Low Gravity Orbit (LGO).

Sounding Rockets

W87-70407 **879-11-38**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET EXPERIMENTS
W. M. Neupert 301-344-8169

The sounding rocket program provides unique capabilities to conduct a broad range of scientific investigations. The program is particularly important for the development and demonstration of the merit of new instruments for shuttle flights and of prototype instruments for satellites. Furthermore, the short lead time and program flexibility make it possible to follow up new discoveries and to study particular phenomena on the Sun and in the Earth's atmosphere. Extreme ultraviolet (EUV) spectra of the Sun are a valuable tool for determining the true physical conditions in the solar corona and in understanding the flow of matter and energy in the sun's outer atmosphere. For this purpose, we need to know the coronal density, temperature, gas velocity, and radiation field. The work under this task is directed toward the development and

flight on sounding rockets of instruments for determining these four physical parameters in the corona. Major objective is to measure coronal gas velocity as a function of position on the solar disk. Another objective is to determine the coronal temperature, density, and line excitation processes by combining a knowledge of line profiles with the relative line strengths. A third objective is the investigation of wave propagation and dissipation, which may be fundamental to understanding energy transport in and heating of the corona.

W87-70408 **879-11-41**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET EXPERIMENTS (ASTRONOMY)
Andrew M. Smith 301-344-8648

The astronomical sounding rocket program provides a unique capability to perform observations from above the Earth's atmosphere. The present objectives are to develop instrumentation which takes advantage of this capability to obtain spatial images of faint extended celestial sources in the vacuum ultraviolet (VUV) and far ultraviolet (FUV). We intend to use two Black Brandt sounding rockets to develop a two dimensional array photon counting detector system which we will use with an existing Ritchey-Chretien telescope to obtain ultraviolet images of active galaxies. The complete system will include a flight memory consisting of 800x800 pixels at 8 bits per pixel; we will propose to use this detector system in a new Spartan instrument. The latter instrument is intended to provide images in the light of FUV and VUV emission lines through the use of a tunable filter. Work on the new instrument also includes design and analysis of the support structure, the primary mirror, the image motion compensation system and the electronics subsystem excluding detector related electronics. Scientific research, primarily concerned with galactic structure and stellar populations will be carried out with data still in hand. New research will be concerned principally with astrophysical plasmas as revealed through the spatial distribution of emission line radiation. Both galactic and extragalactic sources are of interest.

W87-70409 **879-11-46**
Goddard Space Flight Center, Greenbelt, Md.
SOUNDING ROCKET (SPARTAN) EXPERIMENTS (HIGH ENERGY ASTROPHYSICS)
E. A. Boldt 301-286-5853

High energy astrophysics (especially X-ray astronomy) is a rapidly evolving field of research, both scientifically and technically. Our exploitation of the capabilities of short lead time, planning flexibility, accurate pointing and extremely high telemetry rates afforded by rocket-borne experiments are major factors in our success to date; a vigorous elaboration of this activity with Spartan is now necessary for continuing to make timely and important contributions that complement data from our satellite missions and for the effective planning of advanced future missions (e.g., HTM). This involves experiments with systems incorporating newly developed spectrometers and X-ray concentrators.

W87-70410 **879-31-46**
Marshall Space Flight Center, Huntsville, Ala.
X-RAY ASTRONOMY
M. C. Weisskopf 205-544-7740

Research is being conducted in the field of X-ray astronomy in areas related to the Astrophysics programs of NASA. The objectives of this program are: (1) To analyze and interpret existing satellite and ground-based observations of the time variability of X-ray sources and their optical counterparts. To utilize Fourier transform, epoch folding, and auto- and cross-correlation techniques to classify and qualify the time variability of these sources To interpret the results in terms of existing theoretical models or to establish new theoretical models if required and feasible. (2) To develop new methods and systems for detecting X-ray polarization. To design, build, test, optimize, and eventually fly on sounding rockets and/or satellites an advanced X-ray imaging detector which utilizes both fluorescence of the atoms in the detector gas together with parallel field preamplification regions to obtain the highest performance. This has application for X-ray imaging, spectroscopy, and polarimetry.

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

Advanced Systems

W87-70411 **310-10-23**
Goddard Space Flight Center, Greenbelt, Md.
SOFTWARE ENGINEERING TECHNOLOGY
Frank E. McGarry 301-344-6846
(506-54-56; 310-40-49)

The objective of this RTOP is to identify, evaluate, and refine software engineering technology as applied to the software development process for the NASA environment. The technology to be studied includes software development methodologies (such as structured implementation techniques, various testing techniques, structure analysis approaches to design), software development tools (such as code auditors and analyzers, configuration management aids and PDL processors), software measures and models (such as cost and reliability estimation models), and techniques for increasing reusability of software. The identified methodologies are intended to significantly reduce the overall life cycle costs of the software within the Mission Operations and Data Systems area. The approach to attain the stated objectives includes the utilization of an experimentation laboratory wherein proposed tools, methodologies and models may be acquired, developed, applied and studied in an actual software production environment. This laboratory (called the Software Engineering Laboratory (SEL)) first of all identifies technologies of potential benefit to the NASA software development process, then identifies appropriate measures for assessing the impact of the technology and coordinates the detailed experimentation of applying and tuning the technology within selected software development projects supporting various requirements of Mission Operations and Data Systems. Each of the projects is then carefully studied to determine the impact within the NASA software development environment and to further identify refinements or additional technologies (tools, models, methodologies, language characteristics, etc.), that could positively impact NASA software and would be directed at addressing specific NASA software shortcomings.

W87-70412 **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
FLIGHT DYNAMICS TECHNOLOGY
F. L. Markley 301-344-6082

The objective is to develop, evaluate, and demonstrate new technology for flight dynamics in the Tracking and Data Relay Satellite System (TDRSS) and Space Transportation System (STS) era, encompassing algorithms, techniques, software, and hardware for attitude and orbit determination/prediction/analysis for both ground-based and onboard application. The technology developed under this RTOP supports NASA programs in the areas of mission computing and analysis, TDRSS operations, and data processing. The Cosmic Background Explorer Flight Experiment will develop, demonstrate, and evaluate one-way Doppler tracking via TDRSS multiple access return link using an ultrastable oscillator onboard a user spacecraft. Advanced Attitude Sensor Systems will develop and evaluate mathematical models of attitude sensor systems to improve the performance and accuracy of spacecraft attitude systems. Orbit Determination Automation will develop, demonstrate, and evaluate techniques for automating the orbit determination process.

W87-70413 **310-10-60**
Jet Propulsion Laboratory, Pasadena, Calif.
RADIO METRIC TECHNOLOGY DEVELOPMENT
R. N. Treuhaft 818-354-6212
(310-10-61; 310-10-62; 310-10-63)

The broad objective of this RTOP is to design and demonstrate improved techniques of radio metric data acquisition and analysis

as used by the Deep Space Network (DSN) to support navigation and radio science. Most of the work in the RTOP involves experiments which probe navigation error sources. Some of the experiments in the RTOP also address the possibility of increasing the efficiency of navigation measurements. The current approach to improving navigation accuracy largely consists of refining methods of angular spacecraft navigation using interferometric techniques, primarily Very Long Baseline Interferometry (VLBI). Understanding the results of the VLBI experiments necessitates analysis, physical modelling, and calibration of errors affecting the VLBI data. Hardware and software are developed as they are needed to support the above experimental efforts. A small amount of effort is also directed at studying methods of sub-nanoradian angular determination using space-based platforms. Connected element interferometric (CEI) techniques can reduce the need for DSN antenna time and are being studied to increase angular navigation efficiency. Real-time correlation of the CEI data could provide opportunities for on-line integrity testing in addition to removing the data-rate constraint of transporting data on tape or phone lines. Prototype real-time correlator design will be considered in future years. To identify applications for work, potential mission needs for improved radio metric data accuracy and/or efficiency will be identified in cooperation with RTOP 63. Quantitative analyses will begin to match advanced navigation capabilities to envisioned mission needs or enhancements. Techniques to utilize the inherent accuracy of all observables (Doppler, ranging, and angular measure) will be developed into a single estimation procedure.

W87-70414 **310-10-61**
Jet Propulsion Laboratory, Pasadena, Calif.
EARTH ORBITER TRACKING SYSTEM DEVELOPMENT
T. P. Yunck 818-354-3369
(310-10-60; 310-10-63)

The objective of this RTOP is to develop the conceptual design for an integrated system to track Earth satellites--low Earth orbiters (LEOs), highly elliptical orbiters (HEOs), and geosynchronous orbiters (GEOs)-- and to demonstrate its feasibility. The goal is to improve on current tracking accuracy by roughly an order of magnitude in a system that is economically practical to deploy and operate. Nominally, the system should yield position accuracies of a few decimeters or better at altitudes below 3000 km, increasing to 1 to 5 meters at geosynchronous altitude. It will include approximately 9 ground terminals (3 provided by NASA at the Deep Space Network (DSN) sites) which will be compact and will operate unattended. The system will be able to determine the non-DSN receiver locations with respect to the DSN reference sites with few-centimeter accuracy and will be able to provide continuous tracking for a large number of satellites. A further objective of the RTOP is to study the application of this system to prospective NASA missions and to consider, in general, future NASA Earth orbiter tracking needs and the systems that might be used to meet them. The tracking system proposed here will employ signals from the satellites of the Global Positioning System (GPS) being developed by the Department of Defense. The technique employs differential GPS observables constructed from observations made concurrently with GPS receivers on the ground and on low orbiters. Higher orbiters, above about 10,000 km, would carry a beacon rather than a GPS receiver. Differential GPS positioning techniques are analogous to Very Long Base Interferometry (VLBI) positioning techniques used for geodetic baseline measurements and for tracking various deep space missions. Other work includes system design and performance analysis, error analysis software development, study of GPS for use in Earth orientation measurement, and demonstrations of the tracking techniques on the GPS satellites and on LANDSAT-5. Related work is being done under RTOPs 60 and 63, and under sponsorship of the Oceanic Processes and Geodynamics branches of the Office of Space Science and Applications.

W87-70415 **310-10-62**
Jet Propulsion Laboratory, Pasadena, Calif.
FREQUENCY AND TIMING RESEARCH
L. Maleki 818-354-3688
(310-10-60; 310-10-61; 310-20-64; 310-30-68)

The objective of this RTOP is the generation, distribution, and monitoring of precise frequency and time in the Deep Space Network (DSN) in support of radio science experiments and the navigation of planned and anticipated missions. Frequency and timing is the enabling technology for radio-science experiments including gravitational wave detection. Navigation requirements of current and future missions also depend on stable frequency and time technology. The technical thrust of the RTOP is specifically aimed at: the development of low cost, high reliability frequency standards to achieve stabilities in the range of parts in 10(17) for short, medium, and long averaging intervals; development of precise frequency and time distribution systems capable of stabilities of parts in 10(17) for frequency, and 0.1 ns for time, over distances up to 30 kilometers long; and the characterization of the frequency stability of a Deep Space Station (DSS) with an automated real time frequency monitoring capability. The objective of developing precise frequency sources is approached through the development of a trapped mercury ion standard with the potential of parts in 10(17) stability and with a lower cost and higher reliability of operation than the hydrogen maser. The generation of stable frequencies at short to medium averaging intervals is approached through the development of cryogenic oscillators including the superconducting cavity and the cryogenic quartz oscillator. This same approach will provide the means of developing a flywheel oscillator for the trapped ion standard. Hydrogen masers which are the standards currently used in the DSN will also be supported through efforts aimed at the improvement of their performance and their reliability. Optical fiber networks will be used for the precise distribution of time and frequency throughout a DSN complex. The characterization of the end-to-end stability performance of a DSS is directed towards the development of an automated real time monitoring capability to verify stabilities of all subsystems within a DSS.

W87-70416 **310-10-63**
Jet Propulsion Laboratory, Pasadena, Calif.
SPACE SYSTEMS AND NAVIGATION TECHNOLOGY
C. S. Christensen 818-354-7408
(310-10-60; 310-10-61)

The objectives of this RTOP are to: (1) develop techniques to decrease the costs for navigation data processing in the Deep Space Network (DSN), (2) investigate new and novel navigation technologies, (3) develop synergistic relationship with advanced mission planning teams that promotes the optimum growth of both DSN and spacecraft navigation capability. To meet these objectives the RTOP focuses on three primary areas. The first area, navigation technology, identifies and evaluates data strategies for improving deep space navigation accuracies, and enhancing mission capabilities. Radio metric data requirements for new navigation functions, such as asteroid and comet orbiters, are established. Navigation concepts and data strategies consistent with low-cost mission support are formulated and demonstrated using data from current missions. New and novel navigation technologies are investigated. Technology is being developed for improving quasar-relative solar system target body location accuracies. The second area focuses on reducing mission operations costs and increasing reliability by the automation of radio metric data processing. A navigation development system has been implemented using a VAX 11/780 computer. This system serves as the foundation for the development of high speed computer graphics capabilities, the investigation of navigation uses of expert system technology, and the initiation of automated event driven operations and diagnostic procedures. The third area established system level requirements for QUASAT, an Earth orbiting antenna to be used to acquire Very Long Base Interferometry (VLBI) data. Initial objectives are to demonstrate, using TDRSS, the Tracking and Data Relay Satellite System (TDRSS) feasibility of transferring ground based stable frequency

standards to an Earth orbiter and to obtain interferometric fringes using the TDRSS single access antenna and a DSN station.

W87-70417 **310-20-33**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK SYSTEMS TECHNOLOGY DEVELOPMENT
George C. Kronmiller, Jr. 301-344-7313

The objective of this RTOP is to investigate the applicability of new technology in the Tracking and Data Relay Satellite System (TDRSS) era. Selected technology will be investigated by means of feasibility studies, prototype development and demonstration, and by cost and reliability impact studies. A major goal is to investigate the effect of non-Gaussian channel characteristics on the Space Networks (TDRSS and follow on) link performance and develop coding and signal designs which optimize link performance. Associated with this goal are the objectives of validating the analytical predictions by means of tests utilizing the actual network hardware, developing the capability to predict communications link performance against a mission flight time line and utilizing expert systems techniques to enhance system operation and minimize analyst manpower requirements. Other elements associated with achieving this goal are modifications of the Communications Link Analysis and Simulation System (CLASS) to provide a network design and evaluation tool as well as a network user communications system design tool.

W87-70418 **310-20-38**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK COMMUNICATIONS TECHNOLOGY
S. H. Durrani 301-344-7338

The objectives of this RTOP, initiated in FY-86, are: (1) to introduce an efficient high-rate digital telecommunications system into the NASA Communications (Nascom) network; (2) to develop improved interfaces with commercial telecommunications systems; and (3) to investigate new technologies and techniques for use in Nascom. Four new tasks were proposed initially: 300 Mbps modem; high speed packet switch; local area network technology; and automated fault isolation. Each task will span 2 or 3 years and will encompass analysis, simulation, and hardware and software prototype development. It was understood that additional tasks would be initiated as our in-house skills and capabilities increased and as new areas were defined. One of the four tasks (high speed packet switch) was dropped in January 1986, after a vendor survey showed that the needed technology will be almost ready without any investment by us. Instead, two new tasks in a related area were initiated: protocol evaluation; and gateway design. Two additional tasks were identified in January 1986: TDMA scheduling; and network modeling tools. In-house studies were initiated, and the effort will continue in FY-87. Thus the RTOP will have a total of 7 tasks in FY-87. (This excludes two FY-85 tasks--optimum/modulation and coding for fiber optics; and efficient multiplexing for line drivers--which will be completed by October 1986 and April 1987, respectively.)

W87-70419 **310-20-39**
Goddard Space Flight Center, Greenbelt, Md.
VERY LONG BASELINE INTERFEROMETRY (VLBI) TRACKING OF THE TRACKING AND DATA RELAY SATELLITE (TDRS)
Philip Liebrecht 301-344-8003

The objectives of this RTOP are to utilize VLBI Tracking of the TDRS's as an independent measure with which to validate the TDRSS Tracking capability, to demonstrate the application of passive interferometric techniques to improve TDRS trajectory determination, and develop system functional requirements and descriptions for an operational, dedicated TDRS interferometric tracking system. A two-phased approach will be used. During the first phase, experiments will be conducted to demonstrate the feasibility of the technique, and provide data for evaluation of different design alternatives, and comparison with the Bilateration Ranging Transponder (BRTS) derived orbits. The second phase will involve formulating and documenting overall functional requirements and system analysis for a dedicated operational TDRS tracking system.

W87-70420 **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS
R. P. Hockensmith 301-286-9067
(506-61-26)

The objective of the work under this RTOP is to achieve technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems and in telecommunications coding. These developments will satisfy future requirements of Users of NASA networks (spacecraft space platforms and space transportation system payloads) that require near-global coverage through evolving data relay satellite systems (Tracking and Data Relay Satellite System (TDRSS), and other networks as appropriate. The approaches for accomplishing the objective area are to: (1) identify the basic operational space flight requirements; (2) investigate active and passive components and antenna systems; (3) investigate methods of reducing and controlling torque noise induced steering of large high gain antennas; (4) investigate methods of high density and high rate recording and storage; (5) investigate improvements in telecommunication coding of spacecraft generated data; (6) develop system designs to permit User projects to specify proven, reliable hardware with a high confidence level in the performance capability, cost and required procurement cycle; (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

W87-70421 **310-20-64**
Jet Propulsion Laboratory, Pasadena, Calif.
ADVANCED TRANSMITTED SYSTEMS DEVELOPMENT
Rob Hartop 818-354-3433
(310-20-65)

The object of this RTOP is the development of Advanced Transmitter Systems applicable to future Deep Space Network (DSN) missions that also provide the capability to perform radar astronomy on planets, satellites, asteroids, comets and other targets within the solar system. Recently completed at DSS-13 are a 20KW CW 7.2 GHz transmitter and a receiver-exciter subsystem that are currently being used to demonstrate a complete ground station frequency stability of 5 parts in 10(15) when averaged over 1000 seconds. The subsystems have also been used in conjunction with 2 GHz transmitter and receiver subsystems to investigate simultaneous S- and X-band uplink-downlink operations. These tests have demonstrated the technology for simultaneous uplinks at widely-spaced frequencies for future DSN use. Following the successful completion of a feasibility study in FY-85, the detailed design of a 34.5 Ghz gyroklystron was completed in FY-86. Construction of the 400KW tube can begin when funds are available. Concurrently with this contractor effort is the in-house design of a state-of-the-art transmitter system from the frequency standard at 100 MHz to the feedhorn output at 34.5 GHz. This transmitter system will feature advanced technology in several areas including high power (400KW CW) higher-mode generation and conversion, very high phase stability, high reliability, and complete microprocessor monitoring and control. The resulting transmitter technology will be transferable to other frequency bands as well, such as the planned implementation of 200KW 7.2 GHz transmitters on the 70M network beginning in 1991. A new work unit will develop techniques for combining multiple high power sources in an efficient and versatile manner and provide a conceptual design of a common aperture 7.2/8.4.32 GHz feedhorn. A continuing work unit (begun in FY-86) will provide Ka-band systems analysis to define ground systems support requirements, such as those for Mars Observer and Comet Rendezvous Asteroid Flyby.

W87-70422 **310-20-65**
Jet Propulsion Laboratory, Pasadena, Calif.
ANTENNA SYSTEMS DEVELOPMENT
D. Bathker 818-354-3436
(310-20-64; 310-20-66)

The objectives of this RTOP are to develop and demonstrate

electromagnetic, optical, and structural mechanical technology to increase the capabilities of the large antennas in the NASA/JPL Deep Space Network (DSN). Capability improvements include increased frequency band coverage, simultaneous multifrequency operation, increased gain and reduced noise temperature performance, and reduced maintenance and operations costs. Recent developments initiated in this RTOP include common aperture feeds that operate simultaneously at 2 and 8 GHz, 64m antenna structural bracing, two-axis automated subreflector focusing, and 64 to 70m antenna extension with high-precision shaped dual-reflector technology. Present objectives are to: (1) develop a wideband, high-performance beam waveguide system appropriate to the DSN for operational and stable RF performance advantages, (2) achieve high accuracy and stable RF beam pointing consistent with 32-GHz performance, (3) evaluate 70m antenna RF performance and outline an upgrade program containing affordable options, and (4) use microwave holography to achieve high-precision reflector surfaces. The approach uses computational-intensive synthesis and analysis software appropriate to the large high-frequency reflectors, and demonstrations and tests to reduce implementation risks in order to verify analytical models and understand critical areas needing cost-effective improvement.

W87-70423 **310-20-66**
Jet Propulsion Laboratory, Pasadena, Calif.
RADIO SYSTEMS DEVELOPMENT
J. J. Bautista 818-354-6994
(310-30-68)

The objectives of this RTOP are to improve the Earth-based receiving elements of the spacecraft-to-Earth communications link to meet the future navigation, telemetry and science needs of the Deep Space Network (DSN); to reduce the cost of implementation and modification of the advanced receiving elements; and to increase the reliability and decrease the cost of maintenance of receiving equipment and cryogenic systems. The work in the RTOP is devoted to the development of multi-frequency, ultra-low noise amplifiers to cover 2.3, 8.4 and 32 Gz with broad bandwidths and high gain and phase stability. To this end, both 32 GHz masers and solid-state amplifiers utilizing high electron mobility transistors (HEMTs) are being developed, as well as the analytical tools and measurement systems needed for designing and characterizing maser slow-wave structures, HEMT devices, and microwave low noise amplifiers. Additional work is aimed at the development of microwave cryogenic devices using very low loss superconducting materials for fixed and tuneable RFI protection filters and maser slow-wave structures, and to provide for future cryogenic refrigeration needs of low noise amplifiers by improving the mean time between failures (MTBF) and cooling efficiency of present 4.5 K systems and developing a 4.2 to 1.5 K liquefier system appropriate for use on antennas with beam waveguide feed systems.

W87-70424 **310-20-67**
Jet Propulsion Laboratory, Pasadena, Calif.
OPTICAL COMMUNICATION TECHNOLOGY DEVELOPMENT
James R. Lesh 818-354-2766
(310-10-63)

The objective of this RTOP is to develop and demonstrate a Deep Space Network (DSN) support capability for efficient and reliable optical communications in the mid-to late 1990's. The work will concentrate on the definition, design and analysis of communications and tracking systems which would support such future missions, as well as high leverage technologies which have a major influence on the character of those systems. Additionally, the characteristics and generic designs for the optical communications package aboard the distant deep space spacecraft will be studied to the extent of identifying the impact and hence desirability of optical communications aboard future missions. The RTOP will concentrate initially on direct detection optical technology of greatest benefit to outer planet missions, but will also include heterodyne technology for high background level inner planet missions. Determination of actual spacecraft optical equipment requirements, as well as the development of space qualified hardware, will not be part of this RTOP. Design, development, fabrication and testing of laboratory or ground-based demonstrations of optical communications technology will be included in this RTOP. Flight demonstrations of the technology will only be carried through the initial design and planning stages so that appropriate funding can be identified from other sources. It is envisioned that optical communications will be applicable between distant planetary spacecraft and an Earth-orbiting communications and tracking terminal. This terminal is expected to initially be in low Earth-orbit, possible aboard the space station or one of its formation fliers, with future deployments expected in geosynchronous orbit. However, the cost factors and performance characteristics of ground-based communications and tracking will also be examined.

W87-70425 **310-30-68**
Jet Propulsion Laboratory, Pasadena, Calif.
DSN MONITOR AND CONTROL TECHNOLOGY
Bruce Crow 818-354-6016
(310-10-60; 310-10-64; 310-10-70)

The objective of the RTOP is to develop and demonstrate monitor and control technology necessary in the evolution of the Deep Space Network (DSN) over the next decade. JPL has, for 10 years, been pursuing the use of advanced monitor and control techniques to provide more efficient, cost effective DSN operations. Lessons learned from previous RTOP 68 work (e.g., the necessity of fault tolerant system controllers, better sub-system monitor and diagnostics, etc.), in addition to the continued explosive growth of computing power will shape our future course. This RTOP will address the fundamental architectural structure required for the monitor and control system of an evolving DSN by developing a system design and demonstrating it as DSS 13. The DSN currently has several expert systems--all human. These experts understand each subsystem, how the assemblies interrelate, and how to derive the best performance from the system (even under degraded capacity). They are conscious of the users problems and are skilled at knowing what operational flexibility is available to meet the users needs. This RTOP will: (1) provide a facility to capture this knowledge and develop the architecture, (2) produce a subsystem simulator to aid in the development of the station controller, and (3) develop a monitor and control data base. The use of the simulator will reduce the development cost, allow new interfaces to be tested without having to build expensive hardware/software, and aid in the technology transfer to the DSN. The major deliverables from this RTOP will be a demonstration at DSS 13 that will illustrate the improved failure tolerance of the new monitor and control architectures.

W87-70426 **310-30-70**
Jet Propulsion Laboratory, Pasadena, Calif.
NETWORK SIGNAL PROCESSING
W. Hurd 818-354-2748

The purpose of this RTOP is to investigate, develop, test and demonstrate advanced signal processing techniques and equipment which enable the Deep Space Network (DSN) to plan and achieve its performance requirements with improved reliability, maintainability and operability. The largest task is to develop an advanced receiver for the DSN, including carrier tracking, telemetry demodulation and detection and Doppler extraction. Key near-term objectives for the advanced receiver are: (1) to achieve telemetry performance improvements of 1 dB at high data rates (Magellan) to 3 dB at low data rates (Pioneer 10), relative to Block IV receiver performance, (2) to double the existing data rate capability to 1 Mb/s, (3) to achieve frequency stability of 10 to 15 to 10 to 17, including the Doppler extractor, and (4) to improve operability over existing receivers. Long-range receiver objectives include: (1) spread spectrum capability for reduced sensitivity to radio frequency interference (RFI), and (2) gigabit telemetry rate capability. Major objectives of other RTOP tasks are: (1) development of a broadband spectrum analyzer for DSN RFI surveillance at a sensitivity level comparable to the weakest spacecraft signals, and (2) development of custom very large scale integration (VLSI) for application in signal processing systems. Long-range objectives include development of a complete signal processing system including the advanced receiver, precision

ranging, RFI surveillance, frame synchronization and decoding, antenna arraying and future concepts. During FY87 the main tasks are (1) to complete the breadboard advanced receiver and to begin development of the engineering model, (2) to complete analysis of international cometary explorer (ICE) and Voyager symbol stream combining data and to determine parameters and performance for Voyager Neptune implementation, (3) to maintain the current RFI surveillance system, (4) to proceed with development of the new spectrum analyzer, and (5) to develop concepts and prototype VLSI for signal processing.

W87-70427 **310-30-71**
Jet Propulsion Laboratory, Pasadena, Calif.
COMMUNICATIONS SYSTEMS RESEARCH
L. Swanson 818-354-2757
(310-30-70)

The objective of this RTOP is to develop and demonstrate digital communication systems technology required to meet the needs of Deep Space Network (DSN) missions for the late 1980s and 1990s. To meet the continuing needs for efficient and low cost NASA space communications, the RTOP will focus on improving or expanding space communication capability. The work planned will involve three areas: (1) Coding/decoding and modulation/demodulation techniques for the 1990s will be investigated in order to achieve a 2.0 dB reduction in signal-to-noise ratio. This objective will be met by designing, analyzing and comparing coding systems, some of which may require decoding schemes of higher complexity enabled by new very large scale integration (VLSI) circuit technology. (2) Communication efficiency will be improved for the current codes and technology. For example, the use of image statistics to improve channel decoding of current codes may gain as much as 2.0 dB over the current maximum likelihood decoder in the dSN. Another example is that Reed-Solomon decoders could use more information than the current system gives them. Much of this work depends on analysis and computer simulation of various telemetry subsystems for use in evaluating proposed and planned changes in hardware or operations, which is on ongoing activity of this RTOP. (3) New telemetry systems, including decoders for the 2 dB gain, will be developed using microcircuitry technology. This will involve mathematical, algorithmic, and architectural research.

W87-70428 **310-40-37**
Goddard Space Flight Center, Greenbelt, Md.
HUMAN-TO-MACHINE INTERFACE TECHNOLOGY
Walt Truszkowski 301-344-8821

The objectives of this RTOP are to: (1) develop and apply natural man/machine interfaces for space payload and ground control systems including data base management systems, and (2) develop methodologies, models, interface evaluation tools, and guidelines which emphasize the human factor issues associated with man/machine interfaces and interactions. The intention is to apply recent advances in human factors analysis, data base management, and artificial intelligence (AI) to man/machine interface and interaction problems in order to realize development and operational improvements. The approach to be taken is: first, to identify and apply state-of-the-art data/information management technology in the development of interface standards for distributed information access systems; second, to apply human factors analysis, information presentation guidelines and advanced knowledge engineering techniques and methodologies in the development and application of user interfaces to various data/information systems actively used in the mission and data operations environment. The RTOP is supporting tracking and data relay satellites (TDRSS) operations, mission operations, mission support computing, and general systems engineering activities.

W87-70429 **310-40-44**
Goddard Space Flight Center, Greenbelt, Md.
EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS
Dorothy C. Perkins 301-344-5069

Work under this RTOP will demonstrate the potential of expert systems to automate operations and increase operator capacity by handling routine, labor-intensive tasks and by reducing human task complexity. The development and demonstration of pilot projects which capture functions of control centers will facilitate the transfer of this technology into operations. Under this RTOP, expert systems will be developed and applied in selected areas to reduce, eliminate or assist human operator decision-making. Projects will be established with the operational divisions to develop proof-of-concept systems and transfer the technology for operational use. Systems will be developed with a phased approach to allow for early hands-on demonstration of kernel functions to potential users. The transfer of techniques, methodologies and expertise to the operational divisions will be a major goal. This RTOP will also demonstrate the architecture and effects of multiple cooperating expert systems, and will generalize from specific prototypes to multi-application frameworks. It will also support the embedding of expert systems in data systems.

W87-70430 **310-40-45**
Goddard Space Flight Center, Greenbelt, Md.
MISSION OPERATIONS TECHNOLOGY
Larry Zeigenfuss 301-344-6149

The objective of this RTOP is to develop techniques and validate concepts that will improve Spacecraft Control Center operations efficiency, reliability, and reduce mission operations costs. The intent of this effort is to apply and evaluate the latest computer graphics technologies, automation technologies and computer languages in the specific command and control environment where the technologies and languages will be used. The approach to achieving this objective has three major thrusts. First, to study and prototype automation concepts in a spacecraft command and control environment. The spacecraft engineering analysis capability will be developed to enhance the ability of a spacecraft analyst to detect, isolate, and recover from a spacecraft problem. Second, to develop and implement a distributed command and control capability applicable to attached payloads. This thrust will ultimately provide the remote command and control of a spacecraft from the user's location. Third, to assess tools for development of command and control software systems and enhancement of the human/computer language medium. This thrust is presently completing an evaluation of Ada in the command and control environment. The next step for this area is the development of a natural language interface for spacecraft controllers.

W87-70431 **310-40-46**
Goddard Space Flight Center, Greenbelt, Md.
DATA PROCESSING TECHNOLOGY
Frederick W. McCaleb 301-344-5407

This RTOP supports development and utilization of new technology to provide higher performance data storage devices for use in future data capture, data processing and data distribution systems. Task 1 will be to Implement an Optical Disk Digital Data Storage Testbed System capable of operational demonstration of the capabilities of currently available and future commercial Optical Data Storage Devices. Task 2 will be to conduct a requirements analysis and alternative technology trade study to determine feasible data storage solutions for NASA's future high data rate data buffering requirements.

W87-70432 **310-40-49**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS ENGINEERING AND MANAGEMENT TECHNOLOGY
Robert W. Nelson 301-344-4751

The objective of this RTOP is to develop and evaluate systems-level concepts and technologies which will be utilized to optimize the management, operation, and evolution of the Space Tracking and Data Systems (STDS). Major subobjectives are: (1) the development of a systems engineering and management support system for the introduction and consistent use of systems engineering principles and management practices in all phases of the system life-cycle; (2) the development of a database of network models for systems modeling and simulation; and (3) the definition and phased prototype of an advanced software develop-

ment environment. The RTOP approach is to develop associated tools and techniques, apply the techniques to representative problems, and evaluate both the techniques and the results prior to full utilization in STDS. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite System (TDRSS) operations.

W87-70433 **310-40-72**

Jet Propulsion Laboratory, Pasadena, Calif.

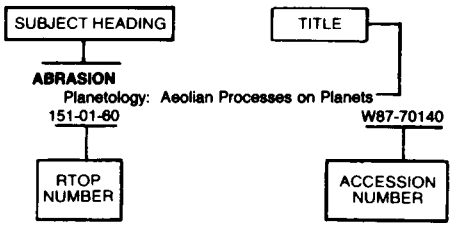
NETWORK HARDWARE AND SOFTWARE DEVELOPMENT TOOLS

S. Peak 818-354-7229

(310-30-70)

The overall objective of this RTOP is to provide Computer-Aided-Design (CAD) tools to Deep Space Network (DSN) engineers which will significantly assist in organizing, conducting, and managing the design and implementation of digital-system hardware. The emphasis of this RTOP on computer-assisted tools for digital-circuit design recognizes the critical importance of taking advantage of the potential benefits of custom integrated circuit designs for building digital hardware for future DSN systems. Many future DSN system applications will require custom circuitry, the design costs of which are still relatively high. It is anticipated that a portion of custom circuits required in advanced DSN systems will be integrated and fabricated on a single chip or set of chips. Sophisticated CAD tools minimize development costs by assuring the accuracy of the design by proper simulation, thus reducing the need for extensive breadboarding and repeated fabrications of the design in silicon. A networked system of in-house, university and commercially developed tools will be available by the start of FY-87 which will accommodate all essential steps in design, verification, and testing. In-house developed tools reside on a VAX 11/780 (VMS) computer. University developed tools reside on a VAX 11/750 (UNIX) workstation. Both sets of tools will be ported to a general purpose VAX 11/750 (UNIX) computer, along with any interface programs. These computers will be networked via ILAN (Interlab Local Area Network) and Ethernet with microcomputers and commercially developed workstations. This networked Design System will be evaluated by (1) implementing DSN circuits as an IC chip or chip set, and (2) utilizing standard cell libraries to implement mathematical algorithms into silicon.

Typical Subject Index Listing



A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

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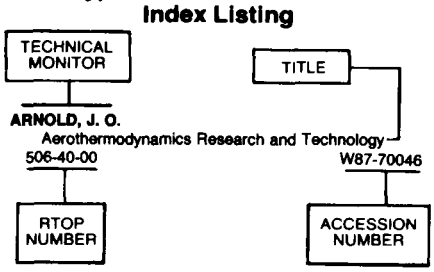

A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

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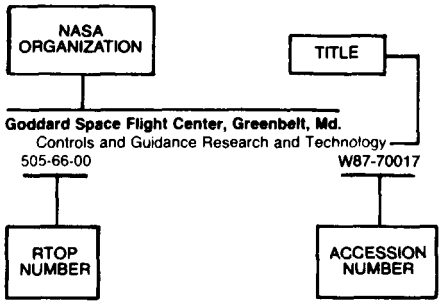

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15. Supplementary Notes

16. Abstract

This publication represents the NASA research and technology program for FY 1987. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The RTOP Summary is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. The first section containing citations and abstracts of the RTOPs is followed by four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

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